



Application of Technology to Transportation Operations in Biohazard Situations

Task 2 Literature Review

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Contents

1	Introduction.....	1
2	Biohazard Agents.....	3
2.1	Definition of Biohazards.....	3
2.2	Specific Biohazard Agents.....	5
3	Biohazard Events.....	13
3.1	Deliberate Release	13
3.2	Agroterrorism.....	19
3.3	Accidental Release.....	19
3.4	Natural Occurrence	20
4	Role of Transportation in Biohazard Situations.....	21
4.1	Release and Spread of Bioagents.....	21
4.2	Detection and Identification.....	24
4.3	Response – Restricted Mobility and Restricted Access.....	27
4.4	Response – Delivery of Prophylaxis.....	29
4.5	Response – Other Transportation Logistics.....	30
4.6	Response – Decontamination.....	31
5	Existing Programs, Plans, and Guidance	33
5.1	Biohazard Response Programs	33
5.2	Federal Response Plans and Guidance	34
5.3	State Emergency Management Plans.....	36
5.4	Local and Regional Plans.....	40
5.5	Transit Emergency Response Guidance	41
5.6	Rail Guidelines.....	43
6	Overview of Applicable Emergency Response Models and Tools.....	44
6.1	Information Sharing Tools.....	44
6.2	Operations Support Tools	44
6.3	Network-Based Transportation Models.....	45
6.4	Biohazard Emergency Planning Support Tools.....	45
7	Conclusions.....	47
	Appendix A: Bioagents Background Information Table	49
	Appendix B: Biological Agents Treatment Table	57
	Appendix C: Examples of Agroterrorism Agents.....	66
	Appendix D: Sample of Biohazard Exercise Scenarios	67
	Smallpox (<i>Variola major</i> virus)	67
	Pneumonic Plague (<i>Yersinia pestis</i>).....	70
	Anthrax (<i>Bacillus anthracis</i>).....	73
	Other Bioagents	75
	Endnotes.....	77

1 Introduction

This document summarizes the literature review conducted for our project, Application of Technology to Transportation Operations in Biohazard Situations. We reviewed a wide variety of materials relevant to the project, including background information on biohazards and biohazard events, documents describing the role of transportation during a biohazard event, and current plans, guidance, and analytical tools for transportation response to biohazard events. This literature review is intended to support all the remaining project tasks, including the tabletop exercise, the development of the concept of operations, and the development of an analytical tool or model.

We identified relevant literature through a variety of means. Following are some of the key sources:

- An extensive bibliography of documents pertaining to chemical, biological, and nuclear terrorism/warfare is available from the Dudley Knox Library of the Naval Post Graduate School, online at <http://library.nps.navy.mil/home/bibs/chemtoc.htm>.
- The Center for Biosecurity at the University of Pittsburgh Medical Center (UPMC) has posted many relevant documents online at <http://www.upmc-biosecurity.org/>.
- The Radio-Television News Directors Association maintains an online list of relevant internet sites and published material at <http://www.rtnda.org/resources/resources.shtml>.
- The University of Minnesota Center for Infectious Disease Research and Policy (CIDRAP) includes an extensive list of bioterrorism research resources at <http://www.cidrap.umn.edu/cidrap/content/bt/bioprep/readings/>.
- *Biosecurity And Bioterrorism: Biodefense Strategy, Practice, and Science*, a quarterly peer-reviewed journal, provides an international forum for debate and exploration of strategic operational issues posed by biological weapons and bioterrorism. <http://www.biosecurityjournal.com/index.asp>
- UCLA's Center for Public Health and Disasters lists useful resource and disaster training materials on its bioterrorism website at <http://www.cphd.ucla.edu/bt1.htm>.

We also reviewed materials available from many Federal government agencies, including the following:

- Office for Domestic Preparedness, <http://www.ojp.usdoj.gov/odp/>
- Centers for Disease Control (CDC), <http://www.cdc.gov>
- Federal Transit Administration (Connecting Communities), <http://transit-safety.volpe.dot.gov/training/Archived/EPSSeminarReg/CD/index.htm>
- Federal Highway Administration (Emergency Response), http://www.ops.fhwa.dot.gov/program_areas/enhancing-etr.htm
- Department of Agriculture, <http://www.usda.gov/homelandsecurity/>
- Food and Drug Administration, <http://www.fda.gov/cber/cntrbio/cntrbio.htm>

The remainder of this document is organized into six chapters and four appendices.

- Chapter 2 discusses the general categories of bioagents and describes key characteristics of specific biohazard agents.
- Chapter 3 discusses four broad categories of biohazard events – deliberate release directed at humans, agroterrorism, accidental release, and natural spread.
- Chapter 4 discusses the role of transportation in biohazard situations, including the release and spread of bioagents, detection and identification, and biohazard response.
- Chapter 5 summarizes programs and guidance that address response to biohazard incidents, including formal guidance and recommendations from government-sponsored studies.
- Chapter 6 reviews a variety of models and automated tools to assist with planning and/or responding to a biohazard event, as well as tools that focus more broadly on transportation operations during emergency situations.
- Chapter 7 contains some conclusions from the literature review.
- Appendix A is a detailed table with characteristics of specific bioagents.
- Appendix B is a detailed table with information on treatment of specific bioagents.
- Appendix C is a list of potential agroterrorism agents.
- Appendix D describes 19 biohazard exercise scenarios.

2 Biohazard Agents

This chapter discusses the general definition of biohazards and describes the broad categories of agents and their environmental characteristics. The chapter then describes key characteristics of specific biohazard agents.

2.1 Definition of Biohazards

A biohazard, as defined by the Centers for Disease Control and Prevention (CDC), is “an agent of biological origin that has the capacity to produce deleterious effects on humans, i.e., microorganisms, toxins and allergens derived from those organisms; and allergens and toxins derived from higher plants and animals.”¹ The term “bioagent” is used interchangeably with “biohazard” and can be associated with naturally occurring or intentional releases in the environment. Bioagents are typically of three main types: bacteria, viruses, and biological toxins.

Bacteria are single-celled organisms that can reproduce in the body and thereby cause disease. In general, bacteria can survive outside their hosts for days to years. In the case of bacterial spores, such as the bioagent that causes anthrax, they can survive in the open environment for decades under the protection of their waterproof outer shell.

Bacterial diseases can generally be treated with antibiotics after exposure to a bioagent, but before symptoms appear. Therefore, one would have to know they had been exposed to the biohazard in order to be effectively treated. Some bacterial agents may have a vaccine to protect against the disease; however, many are not publicly available, or their effectiveness is not proven.

Viruses are significantly smaller than bacteria and cannot replicate on their own like bacteria. They must invade a host cell in order to cause infection and spread disease. In general, viruses are less stable in the open environment than are bacteria. Vaccines are available for some viruses; antibiotic treatment is ineffective.

Biological toxins are naturally found chemicals produced by living organisms (as opposed to manmade toxins used as chemical agents). Biological toxins are generally stable in the open environment. Vaccines are not available to prevent disease from exposure to toxins, and treatment is generally limited to supportive care.²

Biohazards are often colorless, odorless, and are most easily spread undetected as an aerosol. They also can be spread through ingestion, injection, or direct contact. Given their predominately colorless, odorless nature and their ease at being concealed, they are difficult to detect before or during a release. Similarly, biohazards typically elicit nondescript initial symptoms and often require an incubation period of several days to weeks in order to induce illness. Therefore, bioagents are difficult to detect after an attack, as well. Rather than generate an immediate high fatality response, biohazards operate by overwhelming health care facilities, creating panic and chaos.³

Despite biohazards' undetectable nature and general potency in relatively small quantities, many are not good candidates for biological weapons. To be effective as a weapon, a bioagent should have the potential for human-to-human transmission, high infection and mortality rates, limited

vaccination/treatment options or availability, suitable environmental stability, and ability to be produced in mass quantities. The last requirement is particularly cumbersome in that manufacturing weapons grade quantities of bioagents is difficult, and such knowledge is known to be held by few countries (although the knowledge may exist unreported elsewhere).⁴ Based on these characteristics, the CDC has established categories of bioagents. The categories are ranked by level of priority determined by the threat they pose to national security and are shown in Table 2-1 below.

Table 2-1. Bioagent Categories Ranked by Threat Priority

Category	Priority Level	Characteristics	Examples
A	Highest	<ul style="list-style-type: none"> Easily disseminated/transmitted Result in high mortality rates Potential for major public health impact May cause public panic and social disruption Require special action for public health preparedness 	<ul style="list-style-type: none"> Anthrax (<i>Bacillus anthracis</i>) Botulism (<i>Clostridium botulinum</i> toxin) Plague (<i>Yersinia pestis</i>) Smallpox (variola major)
B	Second highest	<ul style="list-style-type: none"> Moderately easy to disseminate Result in moderate morbidity (infection) rates and low mortality rates Require specific enhancements of CDC's diagnostic capacity and enhanced disease surveillance 	<ul style="list-style-type: none"> Brucellosis (<i>Brucella</i> species) Food safety threats (e.g., <i>Salmonella</i> species, <i>E coli</i>) Q fever (<i>Coxiella burnetii</i>) Ricin toxin (from <i>Ricinus communis</i>)
C	Third highest	<ul style="list-style-type: none"> Emerging pathogens that could be engineered for future mass dissemination Easily produced and disseminated Potential for high morbidity and mortality rates Potential for major health impact 	<ul style="list-style-type: none"> Nipah virus Hantavirus

Source: Centers for Disease Control and Prevention (CDC), 2004. "Bioterrorism Agents/Diseases," November 19. Available at <http://www.bt.cdc.gov/agent/agentlist-category.asp>.

Due to their high potential for a major public health impact and high fatality rate, we discuss the diseases caused by Category A agents in some detail below. The majority of the information contained in the following bioagent summaries was excerpted from a series of articles from *The Journal of American Medical Association (JAMA)* that chronicle various bioagents' historical and potential use as biological weapons. The articles represent consensus statements from the Working Group on Civilian Biodefense, a group of experts trained in public health, emergency management, and clinical medicine.

2.2 Specific Biohazard Agents

This section describes specific Category A biohazard agents and discusses their health effects, behavior in the environment, historic use in accidental or intentional events, and treatment. More detailed information, including infectivity, potential for human-to-human transmission, incubation periods, treatment options, and mortality rates can be found for all classes of biohazards in Appendices A and B.

2.2.1 Anthrax

Anthrax is an animal disease caused by the bacterial spore, *Bacillus anthracis* (BA). BA spores are found in soil worldwide where they typically cause anthrax cases in herbivore animals that ingest the spores while foraging. The disease is zoonotic, meaning that it can be spread from animal to animal, from animal to human, but not from human to human. Transmission to humans normally occurs through direct contact with an infected animal, but can also be transmitted by eating meat from an infected animal or inhaling BA spores. Human infection is generally limited to those working in specific industry groups, namely goat hair, wool, or tannery workers.⁵ Cutaneous (direct contact) anthrax is the most common naturally occurring form of anthrax, with 2,000 cases reported annually worldwide.⁶ In the United States, 224 cases were reported between 1944 and 1994,⁷ with one additional case reported in 2000.⁸ Gastrointestinal anthrax (ingestion) is uncommon, and inhalational anthrax is even rarer, with not a single reported naturally occurring case in the U.S. since 1976.⁹

Due to the protective, waterproof nature of the spores (which can survive for decades),¹⁰ their small diameter (1 gram can contain 100 billion to 1 trillion spores),¹¹ lack of odor, inability to be seen, and potential to travel many miles before dissipating, anthrax is particularly well-suited for an aerosolized weapons-grade biohazard. Anthrax has been studied as a bioweapon for over 80 years; although, most national offensive bioweapons programs died out after ratification of the Biological Weapons Convention in the early 1970s. Despite military testing of aerosolized BA by the U.S., Iraq, and the former Soviet Union, only two known cases of bioterrorism with BA spores have occurred.¹² Aum Shinrikyo, the cult that released sarin nerve gas in a Tokyo subway station in 1995, experimented with aerosolized anthrax and botulism at least eight times before the successful sarin attack. The anthrax attacks did not produce illness because the strain used is specific to animals and does not pose a significant health threat to humans.¹³

The second reported case is the 2001 attacks in which BA spores in sealed envelopes were sent through the U.S. Postal Service. Twenty-two confirmed or suspected cases of anthrax were reported in Washington, D.C., Florida, Connecticut, and New York. Inhalational anthrax was the culprit in 11 cases, resulting in 5 deaths, and another 11 cases were from cutaneous anthrax.¹⁴

The only known unintentional, non-naturally occurring release of BA came from a Soviet bioweapons factory in Sverdlovsk, Russia, in 1979. The release resulted in an epidemic.¹⁵

Exposure risk to aerosolized BA is greatest during primary aerosolization, when spores are first airborne. The spores may then settle on surfaces in potentially high concentrations and may later

be re-suspended in the air. Therefore, area-wide decontamination is necessary to help reduce the chance of re-suspension of spores and potential further spread of the disease.¹⁶

A small stockpile of anthrax vaccine (anthrax vaccine adsorbed [AVA] produced by Biopart Corp) is available in the U.S. for military use only. Antibiotics are also readily available to treat the disease and are listed in Appendix B. Prophylaxis is recommended for at least 60 days following exposure to anthrax. Given the lack of human-to-human transmission of the disease, it is not necessary to provide preventative treatment to patient contacts unless it is determined that they, too, were likely exposed to the BA spores at the time of attack. Humans and animals dying from the anthrax must be properly buried or cremated in order to minimize further exposure.¹⁷

2.2.2 Botulism

Botulism is a paralyzing disease caused by the botulinum toxin, which is produced by the bacterium *Clostridium botulinum* (*C. botulinum*) (and in some rare cases, from unique strains of *Clostridium baratii* and *Clostridium butyricum*). *C. botulinum* is naturally found in soil and is not transmittable among humans. Pre-formed botulinum toxin is a foodborne threat that is transmitted to humans by ingestion of foods that are not heated, or are not heated thoroughly (the toxin is susceptible to heat of at least 85°C for five minutes).¹⁸ Almost every type of food has been linked to botulism, with vegetables the most common culprit in the U.S.^{19, 20, 21} Humans are also susceptible to the toxin by direct open wound contact with the bacteria *C. botulinum*, which can then release botulinum toxin once inside the body. *C. botulinum* may also be found naturally occurring in the intestines.²² Manmade aerosolized botulinum toxin poses an inhalational threat as a bioweapon. Fewer than 200 cases of all forms of botulism are reported annually in the U.S.²³

As the most poisonous known substance, botulinum toxin is a desirable bioweapon for its potency, lethality, and ability to debilitate infected people for weeks to months as their paralyzed muscle fibers heal. Given the right dispersion factors, a single gram of crystalline toxin could kill more than one million people.²⁴ Ironically, it is also used for therapeutic medicinal treatment of a variety of conditions in the U.S. The toxin is also easy to produce and transport and is virtually undetectable as it is colorless, odorless, and presumably tasteless. Botulinum toxin has been studied as a bioweapon for at least 60 years. The U.S., Japan, Iraq, the former Soviet Union, Iran, North Korea, and Syria are known to have developed or are thought to be currently developing weapons grade botulinum toxin. Iraq has produced thousands of liters of concentrated botulinum toxin, an amount equal to roughly three times the amount needed to kill the entire human population by inhalation, for use in military weapons. In 1990, Iraq filled missiles and bombs with botulinum toxin, among other bioagents, presumably for use during the Gulf War.²⁵

Between 1990 and 1995, Aum Shinrikyo released aerosolized botulinum toxin in downtown Tokyo and U.S. military bases in Japan. The attacks were unsuccessful due to poor microbiological technique, equipment failing to effectively aerosolize the toxin, or internal sabotage.^{26, 27} Bioterrorism could also be used to simulate a naturally occurring outbreak of foodborne botulism, in the form of either a large-scale outbreak from one meal or restaurant or a series of widely scattered outbreaks.

A number of factors were identified by the Working Group on Civilian Biodefense as indicating a possible intentional release of botulinum toxin. The first sign would be a large number of cases with the characteristic paralysis associated with botulism. An outbreak with an unusual botulinum toxin type distinct from the seven naturally occurring types that are currently detectable might also be suspect. Multiple simultaneous outbreaks with no common source might indicate an intentional foodborne attack. Officials also should be suspicious of an outbreak with a common location and time, but no common dietary exposure. This might suggest an aerosol release. However, the Working Group on Civilian Biodefense recognizes that detection “of a covert release of finely aerosolized botulinum toxin would probably occur too late to prevent additional exposures.”²⁸

Exposure to botulinum toxin can be combated with an equine botulinum antitoxin that is effective against the three most common types of botulism, coupled with supportive care. Antitoxin treatment is crucial as soon after clinical diagnosis of botulism as possible. However, antitoxin quantities are limited. The U.S. Army also has access to an investigational antitoxin that treats all seven known types of botulinum toxin. Antibiotics are not effective against the toxin, but can be useful in treating secondary infections that may coexist with botulism.

2.2.3 Plague

Naturally occurring plague is a zoonotic disease spread from rodents to rodents and rodents to humans by the transmission of the bacterium, *Yersinia pestis* (*Y. pestis*) via flea and rodent bites. Bubonic plague is the most common form of plague and is usually preceded by a massive rodent die-off. Having lost their primary host, fleas then transfer to humans. In rare cases of naturally occurring plague, secondary pneumonic plague can develop in advanced stages of bubonic or septicemic plague. If this occurs, inhalation of respiratory droplets can spread the disease among humans. Large outbreaks of pneumonic plague have occurred in this manner. An intentional release of plague would likely occur via an aerosolized form of *Y. pestis* causing primary pneumonic plague, which would then be spread from human to human via inhalation. An average of 1700 cases of plague has been reported annually worldwide for the last 50 years.²⁹

The plague has been used as a bioweapon in the past. Secret Japanese military dispersed plague-infected fleas over populated areas of China during World War II.³⁰ The U.S. and the former Soviet Union later developed methods to aerosolize the plague. In a worst case scenario involving an aerosol release of *Y. pestis*, the World Health Organization (WHO) estimated the bacteria would remain infectious as an aerosol for one hour for a distance of up to 10 kilometers (roughly 6 miles). They also predicted residents would try to flee the affected areas only to further spread the disease.³¹ While the U.S. stopped its offensive biological weapons program in 1970 as part of the Biological Weapons Convention, the former Soviet Union has manufactured large enough quantities of *Y. pestis* to use in weapons.³²

Pneumonic plague is considered a high threat potential bioagent due to relatively widespread availability, knowledge of mass production as an aerosol, its undetectable nature, high fatality rate, and likely potential for secondary transmission during an outbreak.³³

There is no longer a U.S. vaccine for the plague, and even when it was manufactured prior to 1999, it did not protect against pneumonic plague. However, research is being conducted for

such a vaccine.³⁴ Antibiotics are effective in treating the plague and are listed in Appendix B. Given a strong suspicion or confirmed diagnosis of the plague, treatment should be given to anyone in the affected area with fever or a cough as a precautionary measure. Immediate treatment is crucial to survival of pneumonic plague. Similarly, asymptomatic contacts should be given antibiotics for seven days and be wary of fever or cough.³⁵

Historically, quarantining those infected and their contacts has been the rule for preventing further dissemination of the plague. However, modern experience has not shown widespread dispersion of the disease; therefore, the Working Group on Civilian Biodefense does not recommend isolation of contacts. Rather, they should monitor for fever or cough for the first seven days following exposure. Once the primary aerosol has attenuated, there is no further exposure risk from the environment. Respiratory droplets from infected patients are still of concern. However, *Y. pestis* is inactivated by sunlight and heating and does not survive long in the environment.³⁶ In fact, in cases of a bioterrorism release, the aerosol powder would dissipate long before the first symptoms appear.³⁷

2.2.4 Smallpox

Smallpox is a highly contagious disease spread by inhalation of respiratory droplets containing the Variola major virus or by direct contact with infected persons or linens. Once a widespread disease, smallpox has been eradicated since 1977. Routine vaccination against the virus was ceased in the U.S. in 1972 and worldwide in 1980.³⁸ Smallpox has the potential to be a particularly devastating bioweapon due to the susceptibility of a largely unimmunized population, its high transmission rate, and lack of treatment options.³⁹

Smallpox is thought to have been first used as a bioweapon during the French and Indian War (1754-1767). British soldiers distributed infected blankets to Native Americans, resulting in epidemics killing more than 50 percent of affected tribes.⁴⁰ The discovery of a smallpox vaccine in 1796 greatly reduced the effectiveness of smallpox as a bioweapon.⁴¹ Now that vaccine is no longer regularly administered and existing supplies are limited, the global population is again at risk of an intentional smallpox release.

The former Soviet Union is known to have manufactured the Variola major virus in mass quantities to be used in bombs and missiles. Russia is reportedly working on developing more deadly and contagious strains of the virus, and it is thought that this knowledge might be spreading to other countries.⁴²

Given the delayed onset of symptoms, by the time smallpox is diagnosed, the original quantity of the virus released in the environment would pose no threat of further contagion. However, due to the high transmission rate of the virus (as many as 10 to 20 second-generation cases can result from one case),⁴³ it is crucial to isolate anyone thought to have the virus and ideally those that have come in contact with them. Because it is impractical to identify and quarantine all associated contacts, the Working Group on Civilian Biodefense recommends they be vaccinated and monitored for any smallpox symptoms. It is preferred that patients be isolated within the home in order to minimize the spread of the disease that can easily occur in the close quarters of a hospital.⁴⁴

Vaccination has proven effective in preventing or minimizing the symptoms of smallpox if administered within three days of exposure. Vaccination four to seven days after exposure may help protect against or lessen the severity of the disease. Currently, the U.S. has enough supply of the vaccine to vaccinate everyone in the United States in the event of a smallpox emergency.⁴⁵ After eradication of smallpox in the 1970s, the WHO initially intended to destroy all remaining stores of the Variola major virus outside of its reference laboratories at the CDC in Atlanta and the Institute of Virus Preparations in Moscow, Russia. However, given recent fears of its use as a bioweapon, the WHO has delayed its destruction to allow for the development of new vaccines.^{46, 47} The WHO currently is working to build a 200 million-dose stockpile of the vaccine for use if a bioterrorist attack were to occur. Member countries, including the U.S. have agreed to make commitments to meeting the dosage goal; however, it may take up to three years to complete the stockpile.⁴⁸

Antibiotics are not effective against smallpox itself, but may treat secondary bacterial infections. Dead bodies should be handled as contagious objects and be cremated to eliminate further exposure to the disease.

2.2.5 Tularemia

Tularemia is a zoonotic disease caused by the bacteria *Francisella tularensis* (*F. tularensis*) that is transmitted from animals to humans, but cannot be spread from human to human. Humans can acquire the disease directly from animals if bitten by infected ticks, flies, and mosquitoes or by handling contaminated animal tissues or bodily fluids. *F. tularensis* is also transmittable via direct contact or ingestion of contaminated food, water, or soil. The bacteria can also be inhaled in aerosol form.⁴⁹

Tularemia is almost exclusively a rural disease found in North America and Eurasia, often associated with farming and close interaction with animals. The first epidemics of tularemia occurred in the 1930s and 1940s via waterborne infection in Europe and the former Soviet Union and from direct contact with infected animals in the U.S. Tularemia also has historically been spread in laboratory settings.⁵⁰

Japan first began studying tularemia as a potential bioweapon between 1932 and 1945,⁵¹ and the former Soviet Union may have been responsible for tularemia outbreaks during World War II. In the 1950s and 1960s, the U.S. began its own research to use *F. tularensis* as an aerosol and developed stores of the agent. In response, the former Soviet Union developed its own program that continued into the early 1990s with development of antibiotic- and vaccine-resistant strains. As part of the Biological Weapons Convention, the U.S. discontinued its offensive bioweapons development program in 1970 and had destroyed its bioweapons stock by 1973.^{52, 53}

Naturally occurring airborne tularemia outbreaks related to lab exposure and contact with animal carcasses occur. The largest such outbreak occurred in 1966-1967 in rural Sweden when a weaker, less deadly strain of *F. tularensis* infected more than 600 people from aerosolized bacteria that was stirred up during day-to-day farm work. While *F. tularensis* is highly infectious (it requires only ten to 50 organisms to show illness),⁵⁴ there were no reported deaths.⁵⁵

The Working Group on Civilian Biodefense concludes that an intentional aerosol release of *F. tularensis* would cause the greatest public health damage, rather than a foodborne or waterborne attack. According to the Working Group on Civilian Biodefense, public health officials should suspect an intentional release if there are sudden clusters of cases or if any urban outbreak occurs.⁵⁶ While tularemia has a lower fatality rate than other high threat bioagents such as pneumonic plague or anthrax, its generally longer incubation period and slower rate of progression of the disease from general symptoms to more specific, potentially life-threatening symptoms may cause the disease to pass unknowingly to more people prior to being detected and identified. Identification of *F. tularensis* could take several weeks.

An experimental live attenuated vaccine is available in the U.S. for laboratory and other high risk workers. Another investigational vaccine is currently under review by the U.S. Food and Drug Administration (FDA), but its future availability is uncertain given the extended amount of time (2 weeks) it requires to take effect.⁵⁷ The Working Group on Civilian Biodefense does not recommend vaccination for post-exposure prophylaxis. Antibiotics are effective and available to treat tularemia. See Appendix B for the recommended antibiotics. Exposed people do not need to be isolated, nor do their contacts need to be treated as tularemia is not spread among humans.⁵⁸

2.2.6 Viral Hemorrhagic Fevers

Viral Hemorrhagic Fevers are caused by a suite of viruses belonging to four virus families: Arenaviridae, Bunyaviridae, Filoviridae, and Flaviviridae. The viruses are spread to humans via direct contact with infected animals, through insect bites, or via respiration of aerosolized agents. Outbreaks are commonly limited to rural areas.⁵⁹

The diseases of each virus family and their known or suspected routes of exposure are provided in Table 2-2. More detailed information, including infectivity, potential for human-to-human transmission, incubation periods, treatment options, and mortality rates of the Hemorrhagic Fever Viruses (HFVs) and all potential biohazards can be found in Appendices A and B.

Only certain HFVs possess the characteristics necessary to pose a serious bioweapon threat. The arenaviruses causing Lassa fever, Argentine hemorrhagic fever (HF), Bolivian HF, Brazilian HF, and Venezuelan HF; the bunyavirus causing Rift Valley fever; the filoviruses causing Ebola and Marburg; and the Flaviviruses causing yellow fever, Omsk HF, and Kyasanur Forest disease could be used as bioweapons. However, the viruses causing dengue, Crimean-Congo hemorrhagic fever (CCHF), and hemorrhagic fever with renal syndrome (HFRS) are not considered viable candidates for biowarfare. A covert aerosol attack with one of the HFV bioweapons poses the greatest threat.⁶⁰

The U.S., former Soviet Union, Russia, and possibly North Korea have researched and developed HFVs as bioweapons. The U.S. developed weaponized yellow fever and Rift Valley viruses, and the former Soviet Union and Russia manufactured weapons grade Marburg, Ebola, Lassa fever, Junin (Argentine HF) and Machupo (Bolivian HF) viruses until 1992. North Korea may have developed yellow fever for bioweapon use.⁶¹ Aum Shinrikyo, prior to releasing sarin in the Tokyo subway system in 1995, unsuccessfully attempted to use Ebola virus as a bioweapon.⁶²

Table 2-2. Viral Hemorrhagic Fevers by Family

Disease (Causative Agent)	Exposure Route
<i>Arenaviruses</i>	
Lassa fever	Inhalation of infected rodent excreta or human respiratory droplets; ingestion of food contaminated with rodent excreta; direct contact with rodent excreta (open wound, mucous membranes) or infected human body fluids
Argentine hemorrhagic fever (Junin)	
Bolivian hemorrhagic fever (Machupo)	
Brazilian hemorrhagic fever (Sabia)	
Venezuelan hemorrhagic fever (Guanarito)	
<i>Bunyaviruses</i>	
Rift Valley fever	Direct contact via infected mosquito bites, with infected animal tissues; inhalation of aerosolized virus from infected animal carcasses; ingestion of contaminated raw animal milk
Crimean-Congo hemorrhagic fever	Direct contact via infected tick bites
Hemorrhagic fever with renal syndrome (Hantaan and related viruses)	Direct contact with infected rodents
<i>Filoviridae</i>	
Marburg hemorrhagic fever	Direct contact with infected human or animal tissues or bodily fluids (specific animal reservoirs unknown); injection; inhalation
Ebola hemorrhagic fever	
<i>Flaviviridae</i>	
Yellow fever	Direct contact via infected mosquito bites
Dengue hemorrhagic fever	
Kyasanur Forest disease	Direct contact via infected tick bites
Omsk hemorrhagic fever	

Sources: Borio, Luciana et al., 2002. "Hemorrhagic Fever Viruses as Biological Weapons, Medical and Public Health Management." *JAMA*, Vol. 287, No. 18, May 8.

Jahrling, Peter B. "Chapter 29, Viral Hemorrhagic Fevers," *Medical Aspects of Chemical and Biological Warfare*, pp. 591-602. Available at <http://www.nbc-med.org/SiteContent/HomePage/WhatsNew/MedAspects/Ch-29electrv699.pdf>.

The HFVs exhibit various symptoms and are not quickly confirmed with laboratory testing. Lab results may be further delayed or impossible to obtain during a large attack given current laboratory capacities. Only the CDC in Atlanta or the U.S. Army Medical Research Institute of Infectious Diseases in Frederick, Maryland, is able to even initially diagnose HFVs.⁶³

The only licensed vaccine available for any of the HFVs is the yellow fever vaccine. The supply of the vaccine is limited and would not be sufficient in the case of a large-scale bioattack. Furthermore, yellow fever vaccine is not useful for post-exposure prophylaxis because the virus requires longer to build immunity than it takes the virus to produce illness. Investigational vaccines are available in the U.S. for Junin (causative agent of Argentine HF), Rift Valley fever, Hantaan virus (causative agent of HFRS), and dengue virus. These are not likely to be publicly available in the near future. A vaccine for Lassa fever is under development by the CDC.⁶⁴ In addition, the investigative antiviral drug ribavirin has proven effective in treating some arenaviruses and bunyaviruses, yet it is not approved by the FDA and is available in limited quantities. Passive antibody therapy can be used to treat Argentine and Bolivian hemorrhagic fevers. However, their effectiveness is not conclusively proven, nor is there a national stockpile

available for use in a bioterrorist attack. Overall, treatment for HFVs is largely limited to supportive care.^{65, 66}

Because human-to-human transmission is a possibility only in certain HFVs – namely arenaviruses causing Lassa fever, Argentine HF, Bolivian HF, Brazilian HF, Venezuelan HF, and the filoviruses causing Ebola and Marburg – isolation of those potentially exposed and patient contacts may not be needed. They should, however, be watched for signs of fever or other symptoms. Affected dead bodies should be properly handled and buried or cremated.⁶⁷

3 Biohazard Events

This chapter describes four broad categories of biohazard events, focusing primarily on deliberate release directed at humans, but also describing agroterrorism, accidental release, and natural spread.

3.1 Deliberate Release

A deliberate release of a biohazard directed at humans is generally recognized to be the type of biohazard event that poses the greatest risk to human health and national security. Such an event could be overt (immediately recognized) or covert (unrecognized at the time of release). An overt biohazard event might be identified by the following:⁶⁸

- Previous intelligence,
- A threat of action or post-event claim of responsibility, and
- Direct evidence, such as powder residue or equipment used to release the bioagent, gathered at the release site

The response in an overt situation could be immediate, increasing the chances of limiting those exposed. First responders would be those traditionally involved in an emergency – police, firefighters, and Emergency Medical Services (EMS) personnel.

In a covert attack, as is the case in most biological attacks, there is often no forewarning, making the prediction of when and how an attack might occur impossible. Due to the delayed onset of most diseases caused by bioagents, there might be no indication of foul play until days or even weeks after the initial release. Exposed individuals likely would begin to report generic symptoms accompanied by a fever to healthcare personnel at local hospital and medical centers. The patients likely would be diagnosed with a less severe illness at first. Healthcare facilities might become crowded with patients exhibiting similar symptoms as initial patients begin returning with more severe symptoms. Healthcare workers, at this time, would order initial diagnostic tests, and the responsible bioagent might be initially identified within hours to days of the first reported symptoms. However, results would have to be confirmed through a chain of laboratory command. In-house hospital laboratories would send samples to an intermediate state or local public health agency laboratory that can then pass the samples onto the CDC or other higher level agency, Federal facility, or academic research center for official confirmation. Once a confirmatory diagnosis is made, local officials must decide how to respond. If available for the responsible bioagent, the Strategic National Stockpile (SNS) of vaccine and antibiotics likely would be requested. All the while, those initially infected may be spreading the disease to others, leading to a second generation outbreak of the disease. In the case of a covert attack, delay is likely to occur between the following stages:

- Release of the biohazard and first detection,
- First detection and initial diagnosis,
- Initial diagnosis and confirmatory diagnosis/request of SNS supplies, and
- Request of SNS supplies and distribution to those affected.

Given the delay in detection, medical personnel would be the first responders in a covert biohazard event. Employers and schools may note an increase in absenteeism, which also may help trigger a response.

As discussed in Chapter 2, this generic scenario could unfold in the event of an intentional aerosol release, via intentional contamination of food or water supply, or by infecting animals known to transmit the disease to humans. In order to better understand the types of biohazard events that have been the focus of emergency response preparation, and to understand transportation response options to these events, we reviewed 19 past biohazard exercises conducted. In general, most biohazard exercise scenarios are one of two types: (1) aerosolized release of a bioagent in a crowded shopping mall or (2) aerosolized release of a bioagent at a heavily attended sporting event. In these exercise scenarios, air ventilation systems often are assumed to increase dissemination, extending the reach of an aerosolized bioagent to expose as many people as possible within an enclosed building or subway station. Table 3-1 provides an overview of the exercises we reviewed. A full description of the scenarios and their possible transportation response are detailed in Appendix D.

In addition to the exercises summarized in Table 3-1, the Homeland Security Council (HSC) developed fifteen scenarios for use in national, federal, state, and local security preparedness activities, including four scenarios that involve a deliberate bioagent release.⁶⁹ These include the following:

- An anthrax attack delivered in a single aerosol dispersal by a truck using a concealed improvised spraying device in a densely populated urban city. For planning purposes, it is assumed that the attack includes five separate metropolitan areas, attacked in sequence.
- A plague attack in which an adversary releases pneumonic plague into three main areas of a major metropolitan city – in the bathrooms of the city’s major airport, at the city’s main sports arena, and at the city’s major train station.
- Intentional food contamination in which an adversary acquires restricted documents allowing them to contaminate a beef plant and an orange juice factory using liquid anthrax.
- An agroterrorism attack in which an adversary targets several locations with foot and mouth disease. The disease is spread to many locations in the nation through shipping of livestock. This scenarios involves the transportation system most explicitly as a mechanism for spreading disease.

Each of these scenarios addresses the eight (8) mission areas identified by the Department of Homeland Security, Office for Domestic Preparedness, in its terrorism planning, training and exercise materials. These mission areas include the following:

- Prevention and Deterrence,
- Emergency Assessment/Diagnosis,
- Emergency Management/Response,
- Incident/Hazard Mitigation,
- Public Protection,
- Victim Care,
- Investigation/Apprehension, and
- Recovery/Remediation.

Table 3-1. Summary of Biohazard/Bioterrorism Exercise Scenarios

Scenario	Location of Release	Release Mechanism	First Responder	Number of Days after Release:			Transportation's Role
				First Reported Symptoms	Initial Identification	Confirmed Identification	
Smallpox (Variola major virus)							
Scenario #1	Airports, subway systems, and a marketplace	Aerosol dispensers hidden in backpacks	Not identified	7 days	10-11 days	10-11 days	Delayed response: vaccine distribution; restricting transportation to/from affected cities, states, countries
Scenario #2	Shopping malls	Not identified	Not identified	Not identified (scenario assumes 9 days based on smallpox's incubation period)	Not identified	Not identified	Delayed response: vaccine distribution; restricting transportation to/from affected cities, states, countries; distribution of food and necessities
Scenario #3	University	Aerosol	Healthcare workers	11 days	15 days	15 days	Delayed response: vaccine distribution; restricting transportation to/from affected cities, states, countries
Scenario #4	Shopping mall	Aerosol dispenser with a timer attached to a wall near air circulation vent	Healthcare workers	~ 14 days	~16 days	~ 16 days	Delayed response: vaccine distribution; restricting transportation to/from affected cities, states, countries; distribution of food and necessities
Scenario #5	Not identified	Not identified	Daycare workers; healthcare workers	Not identified (1 st day of scenario)	Not identified (1 st day of scenario)	Not identified (3 rd day of scenario)	Delayed response: vaccine distribution; restricting transportation to/from affected cities, states, countries

	Location of Release	Release Mechanism	First Responder	Number of Days after Release:			Transportation's Role
				First Reported Symptoms	Initial Identification	Confirmed Identification	
Pneumonic Plague (Yersinia pestis)							
Scenario #6	College hockey game(s)	Not identified	Healthcare workers	2-3 days later	4-5 days	4-5 days	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries
Scenario #7	Performing arts center	Aerosol	Healthcare workers	Not identified	Not identified	Not identified	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries
Scenario #8	Not identified	Aerosol	Healthcare workers	Not identified (1 st day of scenario)	Not identified (1 st day of scenario)	Not identified (1 st day of scenario)	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries; transporting corpses; routing traffic around violence/ demonstration points
Scenario #9	Not identified	Not identified	Healthcare workers	Not identified (1 st day of scenario)	Not identified (2 nd day of scenario)	Not identified (2 nd day of scenario)	Delayed response: antibiotics distribution; restricting transportation to/from affected areas; transporting elderly, handicapped, and other mobility-limited people to treatment centers
Scenario #10	Shopping malls	Infected terrorists present in crowded, enclosed areas	Mall security personnel; healthcare workers	< 1 day	1 hour after detaining infected terrorists	1 hour after detaining infected terrorists	Immediate response: restricting auto travel from mall; restricting and re-routing traffic entering mall; directing emergency response traffic to/from hospital and mall for screening/treatment

Scenario	Location of Release	Release Mechanism	First Responder	Number of Days after Release:			Transportation's Role
				First Reported Symptoms	Initial Identification	Confirmed Identification	
Anthrax (<i>Bacillus anthracis</i>)							
Scenario #11	Football game	Truck releases aerosol upwind of open-air arena	Healthcare workers	2 days	4 days	5 days	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries; routing traffic around demonstration/violence points
Scenario #12	Washington, D.C.	Airplane releases aerosol upwind of D.C.	Not identified	Not identified	Not identified	Not identified	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries
Scenario #13	Subway system	Drop light bulbs filled with anthrax simulant (full-scale test scenario) on tracks and in ventilation system	Not identified	Not identified	Not identified	Not identified	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries
Scenario #14	Football game	Crop-duster plane releases aerosol over stadium	Healthcare workers	Not identified	~ 7 days	~ 7 days	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries; routing traffic around demonstration/violence points
Scenario #15	Not identified	Not identified	School nurses; healthcare workers	Not identified (6 days prior to 1 st reported death, also the 1 st day of scenario)	Not identified (1 st day of scenario)	Not identified (8 th day of scenario)	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries

Scenario	Location of Release	Release Mechanism	First Responder	Number of Days after Release:			Transportation's Role
				First Reported Symptoms	Initial Identification	Confirmed Identification	
Other Bioagents							
Scenario #16 Highly Pathogenic Avian Influenza (HPAI)	Not identified	Outbreak occurs in birds	Birds: poultry farmers, veterinarians; Humans: Healthcare workers	Not identified	Not identified	Not identified	Delayed response: restricting transport of infected birds
Scenario #17 Rift Valley fever virus (RVFV)	Not identified	Not identified, but released in area where mosquitoes could be the assumed culprit	Animals: farmers, veterinarians; Humans: healthcare workers	Not identified	9 days	9 days	Delayed response: vaccine/antibiotics distribution
Scenario #18 Foot-and-Mouth Disease (FMD) Rinderpest ^a	Feedlots	Not identified	Animals: ranchers, veterinarians	Not identified	Not identified	Not identified	Animal vaccine distribution; restricting animal and product movement; transporting carcasses; movement of animals to isolation facilities
Scenario #19 Tularemia	Basketball game	Not identified	Healthcare workers	Not identified (1 st day of scenario)	Not identified (1 st day of scenario)	Not identified (1 st or 2 nd day of scenario)	Delayed response: antibiotics distribution; restricting transportation to/from affected cities, states, countries

^a Neither disease is transmittable to humans.

3.2 Agroterrorism

Agroterrorism describes the deliberate introduction of an animal or plant disease with the goal of generating fear, causing economic losses, and/or undermining stability.⁷⁰ The results of an agroterror attack can include major economic crises, loss of confidence in food supplies and government protections, and possibly human casualties. Such threats can be countered on four levels:⁷¹

- (1) at the organism level, by fostering resistance to likely diseases;
- (2) at the farm level, by practicing techniques designed to prevent disease from being introduced or spread;
- (3) at the agricultural sector level, by implementing disease detection and response procedures; and
- (4) at the national level, through policies designed to minimize the social and economic costs of a catastrophic disease outbreak.

Detection sometimes rely on the same mechanisms for identifying, reporting, and tracking natural and accidental disease outbreaks, though specific detection efforts specific to agroterrorism may also be implemented.

The low-density distribution of potential targets represents a major challenge in preventing agroterrorism. An assessment of recent laws related to agroterrorism preparedness and to date can be found in a recent Congressional Research Service report titled, “Agroterrorism: Threats and Preparedness.”⁷² Appendix C lists diseases and agents that are of concern for agroterrorism.

3.3 Accidental Release

An accidental release of biohazards could occur by mishandling of biomedical waste or an accident associated with a laboratory that studies contagious diseases or biological threats. Such accidents may involve accidents during transportation of waste material, damage to laboratory facilities where diseases are studied, or accidental release of laboratory animals infected with diseases. A recent example of a lab-related accidental release occurred last year when three lab workers at a Boston University research facility contracted tularemia after being exposed to the virus through their research. The public was not informed of the accidental release until three months after tularemia was confirmed as the infectious source.⁷³

Some accidental releases have been tied to military bioweapons programs. For example, an ecological research ship passed within nine miles of a smallpox testing site off the coast of the former Soviet Union in 1971. A single crew member became infected, presumably through inhalation of the disease, and carried the virus back to port. The Soviet government has never admitted to aerial smallpox testing; however, a 2002 report prepared by the Monterey Institute of International Studies suggests that an outbreak ensued, killing three people and infecting many, some of whom had been previously vaccinated. Hundreds were quarantined, and nearly 50,000 were vaccinated in response. Travel to and from the port city was banned.⁷⁴

Despite the public hazards of an accidental release of a bioagent, the public health impact is likely to be less severe than for a deliberate release. Therefore, this literature review focuses less on these types of events.

3.4 Natural Occurrence

Bacteria, viruses, and biological toxins that are harmful to humans and animals frequently spread naturally through populations. When large populations are affected or biological responses are sufficiently severe, naturally occurring biohazard events can cause a major public health problem. Widespread natural outbreaks occur for a number of reasons, including the following:

- Natural mutations that make diseases resistant to existing vaccines or naturally occurring antibodies,
- Environmental conditions that favor the development of certain bioagents, and
- Natural cycles of disease agents.

Another naturally occurring biohazard source is the mishandling and improper sanitation of food and water. In the case of food, a single source such as a restaurant that fails to thoroughly cook its meat could be the culprit, causing a localized threat to public health. Contaminated food could also originate from a single feedlot or a cattle-dense region that distributes animal products across the country, potentially resulting in numerous, scattered outbreaks. Leaking septic systems or deficient water sanitation systems could cause water contamination, leading to localized biohazard events.

Overt biological attacks could be confused with naturally occurring outbreaks, especially in foodborne diseases and those spread by animals. The detection and identification process would be the same as described above for a deliberate release. However, in the event of a natural occurrence, the public health impact is likely to be less severe than for a deliberate release. Therefore, this literature review focuses less on these types of events.

The Homeland Security Council (HSC) scenarios⁷⁵ discussed in Section 3.1 also address natural disease occurrence. One scenario deals with influenza pandemics, relating what could happen without an effective preplanned response. In this scenario, at least twenty-five cases occur in a small village in south China and spread to Hong Kong, Singapore, South Korea, and Japan over the following two months. Young adults appear to be the most severely affected with case-fatality rates approaching 5 percent. The virus eventually appears in four major U.S. cities, with ongoing outbreaks as the exercise continues.

4 Role of Transportation in Biohazard Situations

This chapter discusses the role of transportation in biohazard situations. The chapter first discusses the potential role of transportation in the release and spread of bioagents, and in bioagent detection and identification. The chapter then covers transportation during biohazard response, including restricting mobility, delivery of prophylaxis, other transportation logistics roles, and decontamination.

4.1 Release and Spread of Bioagents

Whatever the source or reason for a biohazard situation, transportation systems are likely to play an important role in spreading or preventing the spread of bioagents or disease. The transportation system may spread disease either from a naturally occurring outbreak or from a deliberate attack. Transportation may also cause an accidental release during the transport of biohazard materials. This chapter discusses the role of transportation for several types of biohazard events and then discusses some of the impacts for each mode.

4.1.1 *Transportation's Role in the Release and Spread of Biohazards*

Deliberate Release⁷⁶

The transportation system can function to spread a deliberately released bioagent, or the system itself may be the target of a deliberate release. When the transportation system is not the target, but simply the vector for a deliberate bioterror attack, the situation is somewhat similar to transportation's role in spreading natural disease. The system may carry not only the biological agents, but also the terrorists harboring the bioagents, to the site of an attack on some other venue. The scale of an intentional release, however, is usually different. A deliberate attack may seek to maximize the number of infected individuals, thus increasing the chance that the transportation system will spread the disease to many areas before authorities are aware of the attack and associated infections.

Transportation facilities are attractive targets for bioterror attacks because large numbers of vulnerable passengers congregate in terminals and travel in transit vehicles and airplanes. In addition, most of the nation's goods are delivered by truck and rail or stored in depots and warehouses served by the transportation system. In cases where the transportation system is the target of a terrorist attack that uses a highly contagious agent, the system simultaneously serves as both the target and disease spreading agent. Such a situation might make the transportation system a particularly attractive target to a terrorist. Finally, in addition to having an immediate impact on people or goods, a terrorist organization that targeted transportation facilities could achieve longer-term disruption by making passengers or shippers fearful of using or unable to use the system.⁷⁷

For non-contagious diseases, transportation systems also may play a purely mechanical role in spreading biohazards. By their very nature, transportation systems involve movement of equipment. In cases where aerosolized bioagents have been released in the environment, the movement of transportation vehicles may be an important mechanism for re-suspending and distributing particles that had already settled out of the air.

Accidental Release

Transportation also can play a role in the accidental release of biohazards when a crash or other mishap occurs during the transport of known biohazard materials. Because highway transportation is sometimes used to carry infectious medical materials, such an accidental release is not inconceivable and might create small scale contamination that would disrupt travel along a specific route. However, well-developed response plans and packaging requirements for such substances (known as Class 6 hazardous materials) make a large scale biohazard event from such accidental releases unlikely.⁷⁸

Natural Occurrence

The transportation system plays a significant role in spreading disease for two primary reasons. First, many places in transportation systems have high concentrations of people allowing for diseases to be exchanged directly between passengers, through ventilation systems, or through surface materials. Second, by transporting the disease carriers themselves, transportation systems can quickly carry naturally occurring diseases to areas and populations that have not yet been infected, turning what would have been an isolated outbreak to geographically broader, sometimes global, events.

4.1.2 Modal Differences Related to Biohazard Release and Spread

Each mode has specific characteristics that affect its potential role in the release and spread of biohazards. These characteristics include the physical characteristics of the system and the way the system typically is used. The most important characteristics relate to the degree to which the system concentrates people, the distance and speed of travel, and mechanisms for controlled access. This section briefly highlights the vulnerabilities of each mode in biohazard incidents. Many of these points are summarized in Table 4-1 below.

Highway

The roadway network is a difficult target for bioterrorism, largely because there are few enclosed spaces with high concentrations of individuals. This limits the potential for persistent contamination, as well as the threat of heating, ventilation, and air conditioning (HVAC) system contamination. There are, however, some components of the highway system, such as rest areas, where biological contamination may be a greater concern. In addition, roadways may play a significant role in the re-suspension of contaminants in the case of an aerial attack. Given the diverse travel patterns and moderate speed of travel, the roadway network can play a substantial role in spreading a biohazard between regions and states. Highway rest areas also merit specific consideration as areas potential targets and as sites where diseases may be transmitted. In addition to these issues, the porous materials used to construct roads may present particular challenges for decontamination.

Transit

The transit system includes enclosed spaces such as passenger compartments and, in some cases, tunnels, stations, and terminals. Naturally, subway systems include the highest proportions of enclosed spaces. With a large number of enclosed spaces, there is high potential for persistent contamination and HVAC contamination. Given the potential of infecting a large number of

individuals at once, spread to other modes is a significant threat. The range of many transit systems would generally limit their role to spreading biohazards within a given region. Because transit systems are centrally controlled, their role in disease spread could be limited once authorities are aware of the biohazard situation.

Aviation

Both aircrafts and airport terminals include enclosed concentrated populations that might be attractive bioterror targets. The long duration of many plane flights and re-circulating HVAC systems make the exchange of contagious diseases more likely. In addition, high travel speeds make it possible to carry disease sometimes anywhere on the planet before authorities are aware of contamination. However, the high degree of central control of air travel means that the role of air travel could be eliminated once authorities are aware of a biohazard situation.

Rail

For intercity passenger rail, characteristics are similar to transit, except that the system may carry infectious agents a greater distance before authorities are aware of any problem. Rail also has the potential for spreading biohazards through livestock, agricultural products, and other cargo. Rail lies between highway and aviation in terms of the degree of central control once an incident has been identified.

Maritime

Cruise ships are a significant potential target for bioterror because of the high concentration of people. However, in terms of effectiveness in spreading disease, the slow speed of cruise ships increases the likelihood that the situation will be recognized before significant spread occurs. Like rail, ships present an opportunity for agricultural cargo contamination and also offer some opportunity for centralized control if a biohazard event is recognized.

Table 4-1: Summary of Modal Characteristics Related to Biohazard Release and Spread

Biological Vulnerabilities	Highway	Transit	Aviation	Rail	Maritime
Enclosed Space	Passenger compartments, tunnels, and rest areas	Passenger compartments, tunnels, stations and terminals	Aircraft and airport terminals	Railcars and tunnels	Cruise ships
Potential for Persistent Contamination	Moderate	High for Stations and Passenger compartments	High for Airports and Aircraft	High for Stations, Passenger trains	High for Cruise ships, Terminals
Ease of Decontamination (Low = difficult)	Moderate*	Low	Low	Moderate*	Moderate
Re-suspension of Deposited Contamination	High	High	Moderate	High	Low
HVAC spread contamination	None	Within Passenger compartments, Terminals	Within Airports, Aircraft	Within Passenger car, Station	Cruise ship, Passenger terminals
Drinking water contamination	None	Passenger drinking water	Passenger drinking water	Passenger drinking water	Passenger drinking water
Ability to Contaminate other modes	Yes	Yes	Yes (Airports)	Yes	Yes (Docks)
Agricultural Cargo Contamination	Yes	No	No	Yes	Yes
Transport Pathway Contamination	Yes (Roads, Rest Areas, Runoff)	Yes (Transit routes)	Yes (Airports)	Yes (Tracks)	Yes (Docks, Harbors, Canals, Rivers)

Source: Science Applications International Corporation (SAIC), 2004. *Draft Report, NCHRP Project 20-59(19)*

* Decontamination for highway and rail modes is given a moderate difficulty ranking above. However, there are some unknowns that could make decontamination of such facilities difficult. These unknowns include the degree of absorption of bioagents into porous asphalt, the transport of bioagents into gravel drainage systems, and the challenges associated with bridge decontamination.

4.2 Detection and Identification

Biohazard detection is traditionally conducted by public health and military officials. For a number of reasons, however, detection is also an important consideration for transportation officials. First, since the transportation system is often the last opportunity to catch bioagents before they spread, the transportation network is a logical focus for detection efforts and technology. Second, the point at which a biohazard is detected during the course of an event can drastically affect the appropriate role for transportation response. For example, if bioagents are detected soon after release, the transportation system may have a much larger role in support of specific evacuation and quarantine requirements. In contrast, if detection occurs several days after the presence of bioagents, transportation may play a smaller role in these activities. Thus, the research and planning priorities for transportation officials depend somewhat on likely detection technologies. This section briefly reviews some of the major technologies and programs for detecting and identifying biohazards.

4.2.1 *Detection Technology*

From a transportation perspective detection can be important at a number of stages. Urgent response would be required for detection of an approaching cloud of potential bioagents (called “standoff” detection). This could merit immediate response and highly coordinated transportation system mobilization. In this case, a detector may simply provide notice of an approaching cloud. Then, depending on the general category of materials in the cloud (e.g., biotic vs. non-biotic), more sensitive detectors could be used and the appropriate authorities notified.

Currently a wide range of technologies are available for detecting and identifying different types of biohazards, but existing technology is not adequate for a widely dispersed network of detectors that could reliably identify the existence of bioagents in developed areas. There is substantial ongoing research in this area and a number of promising technologies.⁷⁹

Distance Detection

For standoff detection, LIDAR (Light Detection and Ranging) equipment is the most promising technology. From many miles, LIDAR can detect the shape of a cloud, which can provide some insight as to whether it was artificially dispersed. From closer range, current LIDAR systems can reliably distinguish whether a cloud is biological in nature, though this may also include benign pollen, molds, and agricultural fertilizers. Current LIDAR systems are not designed for continuous monitoring, but can be used both to track and identify agents once the agent is detected and as an active probe to scan suspect areas. Today’s systems are bulky, relatively complicated, expensive, and require training to operate and maintain. However, current research suggests that LIDAR systems may become much more versatile and practical.⁸⁰

The Department of Energy’s Brookhaven National Laboratory recently received a patent for an advanced portable LIDAR system. The military expects to test another version, the Joint Chemical Spill Detection System, in 2005. Yet another model, the Joint Biological Standoff Detection System (demonstrated in October 2004), uses LIDAR technology to track and ID agents up to five km (3 miles) away. This system uses a combination of LIDAR applications for long-range detection and short-range identification. For domestic use, LIDAR applications research is mainly focused on post-detection missions, such as identification and tracking during biohazard events. However, advances in detection equipment open the possibility of perceiving imminent arrival of bioagents. As one example, implementation of the Autonomous Pathogen Detection System (developed at Lawrence Livermore National Laboratory) would provide continuous monitoring of specific domestic areas. Currently, however, there is no practical technology that can serve as a highly distributed, day-to-day monitoring system for civilian purposes.⁸¹

Point Detection

Point detectors can be used when an actual sample is taken from a cloud of particles. Point detectors may use a variety of mechanisms for assessing the presence of biohazards. For example, an aerosol particle sizer (APS) detects unusual or uniform concentrations of particles that are small enough (0.5 to 20 microns) to embed in alveoli in the human respiratory system.

This would suggest artificial weaponization of the subject material and would motivate more specific tests.⁸²

Point detectors that sense a specific bioagent are also available; although, many have significant shortcomings. For example, genetic detection is biologically specific and fairly fast, but requires significant preparation, as well as a clean, liquid sample. Similarly, mass spectrometry is reliable for specific detection, but is too bulky and expensive to be considered for first responders. Traditional Petri dish cultures are accurate and inexpensive, but confirmation is slow.⁸³

These bioagent-specific detectors could be important tools for transportation responders in a biohazard situation. For example, these technologies could flag the presence of a biohazard within a transportation system before passengers leave the enclosed system. Early detection could aid in providing appropriate quarantine until the situation is confirmed. These types of detection tools are not well developed and face some significant problems, including both false positives and false negatives. Given the drastic measures that are required if detectors identify the presence of a dangerous bioagent, false positives (i.e., inaccurately signaling the presence of a specific biohazard agent when there is none) could potentially waste significant economic and human resources.

Although current methods that provide reliable specificity may not provide a signal until a large number of people are infected, regular sampling and identification of bioagents can still play an important role in reducing the time between infection and response. A few promising bioagent-specific technologies are described below.

- *Surface Acoustical Wave (SAW) Systems* – SAW systems use materials that produce electrical current when subjected to slight changes in mass. These materials are coated with antibodies or complimentary nucleic acid sequences that bind with specific target bioagents. The presence of the antibodies or nucleic acid sequences causes a change in mass, which produces a subsequent change in electric current. This change is measured and alerts to the presence and, possibly, the identity of the bioagent. SAW systems can be fairly sensitive, detecting the presence of bioagents in very low concentrations.⁸⁴
- *Immunoassays* – Immunoassays are available as individual test strips or handheld kits. Immunoassays mimic the immune system by providing specific antibodies that bind selectively with specific biological agents, similar to SAW systems. Fluorescent compounds are then used to detect the presence of chemical binding between the antibodies and bacteria, toxins, or other microbiological organisms. Analysis requires less than twenty minutes for analysis. Though easy-to-use, these quick and disposable immunoassay tests are not currently sensitive enough to capture low concentrations. For example, one of the best test strips for *Bacillus anthracis* (the causative agent of Anthrax) requires more than 10,000 spores for a positive reading – this is more than the number necessary to cause infection.⁸⁵ In some cases, they also generate unacceptably high false positive rates. This can occur, for example, when closely related but non-pathogenic bacterial species are present. Despite these problems, immunoassays show some promise as research improves their sensitivity and the range of bioagents they can practically detect.⁸⁶

4.2.2 Detection Programs

Biowatch

Biowatch is a joint U.S. Environmental Protection Agency (EPA) and Department of Homeland Security (DHS) program that monitors 500 air filter stations across 31 U.S. cities. The filters are collected every 12 hours and then tested in a lab for agents. In the case of contagious diseases, this system will not provide detection before significant spreading occurs. In many cases, however, it will provide detection much earlier than waiting for symptoms to appear in numerous individuals. It may also allow for treatment earlier in the disease cycle, minimizing victim mortality, as well as the necessary level of ongoing treatment.⁸⁷

Biohazard Detection System (BDS)

Biohazard Detection System units are currently being installed in postal centers around the country. A BDS unit consists of an air-collection hood, a cabinet where the collection and analysis devices are housed, and a local computer network connection. The BDS equipment continuously collects air samples from postage canceling equipment while the canceling operation is underway. The system creates a liquid sample and uses DNA matching to detect the presence of anthrax (*Bacillus anthracis*).

The system concentrates air samples over the course of a one hour period. While the sample test is performed (requiring 30 minutes), the BDS is simultaneously concentrating particles for the next sample. Thus, the first result requires approximately one and a half hours; subsequent results are obtained every hour. In the future, BDS can be adapted to test for other biological threats and may be applicable to a broader range of settings.⁸⁸

4.3 Response – Restricted Mobility and Restricted Access

Travel restrictions might be a significant component of the response to a biohazard situation. Restrictions would serve two primary objectives: 1) controlling travel to prevent the spread of biohazards beyond already infected areas and 2) rearranging travel routes so that transportation can function efficiently without approaching potentially infected areas. There is limited literature discussing these two roles for transportation as they pertain specifically to biohazard situations. However, some lessons are apparent from a number of documented exercises (discussed in general in Chapter 2 and detailed in Appendix D).

4.3.1 Restricted Mobility to Prevent Disease Spread

Road closures, transit restrictions, and air and sea port closures might play an important role in preventing the spread of disease agents from an exposed area. Generally, local or state public health officials would implement quarantine. When infectious disease could potentially cross state lines, the federal government has the authority to enact quarantine, with specific closure actions taken by the CDC.⁸⁹ Transportation authorities might exercise specific plans for such closures, usually in response to scenarios involving likely bioterror targets such as stadiums or shopping malls. However, because the location of such attacks likely would remain unknown, transportation agencies must also have general approaches for how appropriate closures would be determined and implemented.

The effectiveness of mobility restrictions in preventing the spread of disease depends heavily on early warning. In many plausible scenarios, a contagious disease associated with a bioterror attack may not be discovered until infected individuals have spread throughout the country. Depending on the degree of disease contagiousness, small scale travel restrictions might not provide any certainty of disease containment. Nonetheless, such travel restrictions around the area of the attack might still be useful for limiting the probability of transmission.

In most envisioned biohazard situations, the area of restricted mobility would be much larger than a neighborhood or city and would affect national and, possibly, international transportation considerations. Many of the scenarios summarized in Appendix D involve access restrictions at the state or national scale, such as closure of highways at state or international borders, in order to prevent infected individuals or vehicles from spreading a bioagent.

4.3.2 Restricted Access to Prevent Exposure

In many cases, action would be required in order to maintain transportation systems, while avoiding contaminated areas. If the contaminated area were relatively small (on the scale of a neighborhood), adjustments for typical commute and local transit routes might be necessary. For example, in a case where there is an immediate recognition of contamination at a major event or in a transit system, it might be necessary to address access routes that allow the rest of the city or region to continue basic transportation operations without traveling through the affected area. Local access restrictions also may be needed to route transportation around demonstration and violence points, as described in several exercises in Appendix D.

If the biohazard were to spread throughout a state or the nation, the process for maintaining a functioning transportation system would be entirely different. Such restrictions would require a reorientation of typical freight transportation flows, including modifications of national and global supply chains, to avoid potentially affected states or nations.

4.3.3 Tool for Restricting Mobility and Access

A number of transportation operations tools and technologies can support efforts to restrict mobility and access. Some examples include the freeway and arterial management technologies listed below:

- Ramp controls,
- Variable message signs,
- Phone and internet based traveler information systems,
- Highway Advisory Radio,
- Traffic signals, and
- Emergency operations centers (EOCs) that coordinate a wide range of operations equipment (e.g., cameras, radios, web sites, HOV/Managed lanes, message signs, and other technologies listed above)

Little research exists that specifically addresses how these tools will be employed during a biohazard event. However, several efforts have examined the general use and coordination of

traffic management centers toward such ends. Chapter 6 reviews models and other tools that are available or under development for the purpose of addressing transportation response to emergency situations, including biohazards.

4.4 Response – Delivery of Prophylaxis

Delivery of prophylaxis such as vaccines and antibiotics is likely to be a critical component of transportation system response. In simulation models for bioterror attacks, such as an overt anthrax attack on a major population center, failure to deliver sufficient medicines is identified as a factor contributing to tens of thousands of additional deaths.⁹⁰ Maximizing transportation capabilities for prophylaxis delivery requires a high level of operations coordination between Federal agencies, local transportation officials, and public health officials.

4.4.1 Strategic National Stockpile

The CDC's Strategic National Stockpile (SNS) holds medicine and medical supplies for use during public health emergencies that are severe enough to cause local supplies to run out (e.g., terrorist attacks, flu outbreaks, earthquakes). A system has been established such that, from the time Federal and local authorities agree that the SNS is needed, medicines will be delivered to any state in the U.S. within 12 hours. A range of packages for various response scenarios have been configured at the SNS to be immediately loaded onto either trucks or commercial cargo aircraft for the most rapid transportation.⁹¹

Individual states are responsible for planning how they will receive and distribute SNS medicine and medical supplies to local communities. However, at the same time that SNS supplies are being sent, the SNS Program will deploy its Technical Advisory Response Unit (TARU). TARU staff are trained to coordinate with state and local officials so that the SNS assets can be efficiently received and distributed upon arrival at the site.

4.4.2 Local Distribution

Depending on the nature of a biohazard event, distribution of prophylaxis from locations within each state may be the most significant transportation challenge. A survey in 2003 indicated that only two states have reported that they are prepared to deploy adequate personnel to break down the SNS drugs, antidotes, and medical supplies once they arrive.⁹² However, significant ongoing training and investment have been made in this area. For example, the CDC recently sponsored two web casts:

- Mass Antibiotic Dispensing: A Primer (June, 2004)
- Mass Antibiotic Dispensing-Managing Volunteer Staffing (December, 2004)

Additional programs, such as the Cities Readiness Program described in Chapter 5, also focus on how prophylaxis will be dispensed once it arrives at the target community. However, amidst all these programs, it is not clear whether states and localities have addressed transportation considerations with regard to local distribution in a sufficiently detailed fashion.

Approaches may be considered in three main categories. In one approach, people who are healthy will be asked to go to a designated central location to get medicines that will keep them

from getting sick. This approach helps ensure that hospitals are able to continue treating their existing patients and others who get sick as a result of the emergency. Another approach involves delivery of medicines and supplies, most likely by U.S. Postal Service employees. This may be called for if it is desirable to minimize public travel. In the third approach, mechanisms suitable for their own specific situations would be identified and developed by cities and states.

4.5 Response – Other Transportation Logistics

A range of additional considerations come into play for transportation response during a biohazard event. Support for other emergency functions, including additional medical support, transportation during evacuation, and adjustments to transportation operations in response to mode shifts, may be required.

4.5.1 Additional Medical Support

In addition to the distribution of prophylaxis discussed above, transportation support will be needed for a range of medical services. These services may include the following:

- Directing emergency transportation to and from hospitals. (This was addressed in the Mass Casualty Exercise: Plague Outbreak which is summarized in Appendix D, #10);
- Transport of infected patients to an area that has facilities that can handle them;⁹³
- Transport of elderly, handicapped, and others who cannot drive. (This was addressed in the Richmond, Virginia, Bioterrorism Exercise which is summarized in Appendix D, #9); and
- Transport of dead bodies. This can be particularly critical for disease situations and requires special transport considerations. (This was addressed in the Massachusetts Integrated Statewide Exercise Program, which is summarized in Appendix D, #6.)

4.5.2 Chain of Custody

There are specific chain of custody demands when there is a credible biohazard threat and material must go through Federal Bureau of Investigation (FBI) laboratory test procedures. Material must be considered physical evidence in a criminal investigation in these instances, and must therefore be handled and accounted for by appropriate law enforcement authorities at all stages of its transport to testing facilities. Chain of custody requirements can place significant demands on law enforcement and transportation officials during times when the public may report numerous instances of suspicious material.⁹⁴ This is likely to occur at the same time that there are heightened requirements to protect critical assets and to respond to other suspected threats. For these reasons, it is valuable to consider strategies for maintaining chain of custody requirements at times when there are high demands placed on law enforcement personnel.

4.5.3 Providing Supplies to Quarantine Areas

Another transportation response requirement that goes hand-in-hand with restricted mobility is increased supply requirements. Supplies that typically are picked up by consumers themselves would need to be delivered. Such demands would be most extreme when there is a quarantine that requires delivery of supplies to individual houses or numerous quarantine facilities.

In addition to the basic demands of increased supply delivery, specific training and logistics may be needed for those making deliveries to infected areas. This may, for example, require training vehicle operators to take over vehicles at particular points, or it may require decontamination centers to treat vehicles that are providing supplies to contaminated areas.

Some of these supply delivery issues associated with quarantine have been raised in a number of bioterror exercises including the Dark Winter Smallpox Exercise⁹⁵ and Smallpox Attack on a Shopping Mall,⁹⁶ both summarized in Appendix D.

In the event that major transportation facilities are closed or service is reduced, there is the potential that critical supplies will run short in urban areas. This possibility was highlighted recently when rail transport of hazardous materials was suspended for 72 hours at the start of U.S. military action in Afghanistan. As a consequence, water treatment plants at several locations throughout the country were running critically low on chlorine used to maintain drinking water standards. (Planning for these secondary impacts of transportation response actions is the main objective of NCHRP project 20-59 task 19, discussed briefly in Chapter 6.)

4.5.4 Mode and Location Shifts

Dramatic shifts in mode choice should be anticipated during a biohazard event. Within the affected area, and potentially throughout the nation, one would expect decreased transit and air travel since people are likely to fear exposure to infected people due to the high volume of people in enclosed spaces, such as a subway station or airport terminal. In the areas with biohazard emergencies, transportation officials will need to anticipate these changes in travel patterns in order to avoid traffic conditions that severely constrain emergency response. In areas where there is not imminent emergency, transportation officials should be prepared for the possibility of severely altered traffic patterns. Similarly, there may be a significant shift away from population centers in both infected and non-infected areas. This may alleviate some traffic conflicts with emergency response, but may also place unique demand on supplies and traffic in areas that normally have low population densities.

4.6 Response – Decontamination

Decontamination requires inactivating or killing bacteria, viruses, and toxins. The effort and techniques required for decontamination varies dramatically depending on the type of bioagent. Some viruses and bacteria in their vegetative phase, for example, are relatively frail and more easily decontaminated, or they may rapidly become inactive with no decontamination at all. Bacteria that form spores, such as the causative agent of anthrax, *Bacillus anthracis*, are extremely difficult to inactivate. Toxins have varying degrees of resistance, but can be inactivated by many of the materials used for decontamination, such as hypochlorite or chlorine.⁹⁷ The environmental persistence of specific bioagents is addressed in Appendix A.

There are both chemical and physical methods for decontamination. The primary chemical decontaminant is a 5% hypochlorite solution. Hypochlorite should be left in contact with surfaces for 30 minutes and requires follow-up washing with soap and water. Physical methods of decontamination include heat and radiation. To render most agents completely harmless, dry

heat at 160°C (320°F) should be applied for two hours. Alternatively, steam heat applied at 121°C (250°F) under 1 atmosphere (atm) [15 psi] of pressure may reduce the time required to deactivate the bioagent to 20 minutes depending. This last method is also known as autoclaving.⁹⁸

In enclosed spaces, fumigation is often an appropriate decontamination technique. Common fumigants include chlorine dioxide, methyl bromide, para formaldehyde, ozone, vapor hydrogen peroxide, and ethylene oxide. For example, chlorine dioxide was recently used for the remediation of the Hart Senate Office Building and the Brentwood U.S. Postal Distribution Center, while vapor hydrogen peroxide was used successfully by the Department of State to decontaminate a mail sorting facility in Sterling, Virginia, outside of Washington, D.C.

For outdoor contamination, there are a number of treatment options. For surface decontamination, disinfecting solvents, foams, gels, or emulsions are common. Foam increases the time a surface is exposed to a disinfectant, which may increase the effectiveness of or allow for less concentrated doses of the decontaminant. Removal or clean-up of the disinfectant is required following the appropriate contact time. Decontamination can have additional health and environmental implications, such as runoff into water sources.

Few resources are available to guide decontamination procedures, such as how decontamination facilities would be set up for transportation vehicles to enter and exit an affected area, during a large-scale biohazard response. It is also unclear whether transportation and other response agencies have considered whether the appropriate decontaminants are available in the quantities that would be necessary to continually disinfect emergency response and delivery equipment.

5 Existing Programs, Plans, and Guidance

This chapter summarizes programs and guidance that address response to biohazard incidents. This includes formal guidance and recommendations from government sponsored studies.

5.1 Biohazard Response Programs

5.1.1 *Biowatch*

This program was discussed in section 4.2 because it is primarily focused on biohazard detection.

*BioSense*⁹⁹

BioSense is an initiative to improve capabilities for near real-time disease detection and surveillance by making better use of anonymous patient data from existing health-related databases. BioSense seeks to systematically examine data from several national sources to help public health officials detect health trends to more quickly identify disease epidemics or attacks. BioSense would draw on data sources, such as requested lab tests, over-the-counter drug sales, and managed care hot lines. Much of the data proposed is already collected on a regular basis and could be relayed to public health officials for analysis.

Phase One was released to a number of metropolitan reporting areas in April 2004. The system provides access to time series and geographic views of indicators for all involved jurisdictions. Phase One also establishes the CDC BioIntelligence Center (BIC) to monitor incoming data, identify potential outbreak signals, facilitate investigation, and support consequence management. The BIC also will support local health departments in interpreting data and in working effectively with data providers. Phase One data sources include Department of Defense (DoD) and veterans affairs (VA) medical treatment facilities, Biowatch lab results, over-the-counter drug sales, and national clinical lab test orders.

*Cities Readiness Initiative*¹⁰⁰

Twenty cities and the National Capital Region (District of Columbia) are participating in a pilot program aimed at enhancing collaboration during large scale public health emergencies, including bioterrorism and other biohazard events. The U.S. DOT is not a key partner in this program, but it does include a diverse range of other Federal offices.¹⁰¹ The Initiative is focusing significant attention on how to distribute stockpile medicines, but will also identify and disseminate examples of robust and well functioning state and local plans and capabilities.

5.1.2 *Metropolitan Medical Response System*¹⁰²

The Metropolitan Medical Response System (MMRS) Program began in 1996 and currently is located in DHS. On March 1, 2003, MMRS joined the Federal Emergency Management Agency (FEMA) and other programs from the Departments of Health and Human Services, Energy, and Justice to become the Emergency Preparedness and Response Directorate of the new DHS. The program provides funding to larger cities to develop programs to:

- Prepare responders for rapid deployment to any incident involving nuclear, chemical, or biological agents;
- Facilitate appropriate measures to curtail public endangerment (e.g., identify the agent);
- Extract, decontaminate, and transport victims to appropriate medical facilities);
- Coordinate medical treatment (e.g., primary medical care, provision of antidotes, in-patient medical care, and psychological counseling) for those affected (e.g., victims, responders, and patient contacts); and
- Arrange for disposition of casualties.

All metro area fire departments, police departments, 911 hospitals, public health agencies, EMS agencies, and emergency planning and response agencies have been asked to participate.

5.1.3 National Biodefense Analysis and Countermeasures Center¹⁰³

The DHS National Biodefense Analysis and Countermeasures Center (NBACC) will provide the nation with essential biocontainment laboratory space for biological threat characterization and bioforensic research. Construction of the NBACC facility is scheduled to begin this year and is expected to be completed in 2008. The Center will be located within the National Interagency Biodefense Campus at Fort Detrick, Maryland. NBACC will research infectious properties of biological agents, effectiveness of countermeasures, decontamination procedures, and forensics analyses to support policy makers and responders' development of policies, programs, and technologies. NBACC is part of a nationwide group of institutions that collectively are referred to as the Homeland Security Biodefense Complex. The Complex includes the Plum Island Animal Disease Control Center, the Biodefense Knowledge Center, the national laboratories, and the university-based Homeland Security Centers of Excellence.

NBACC will be comprised of the following:

- The National Bioforensic Analysis Center (NBFAC), which will conduct and facilitate the technical forensic analysis and interpretation of materials recovered following a biological attack in support of the appropriate lead Federal agency.
- The Biological Threat Characterization Center (BTCC), which will conduct studies and laboratory experiments to fill in information gaps. Research may be conducted to better understand current and future biological threats, assess vulnerabilities, conduct risk assessments, and determine potential impacts in order to guide the development of countermeasures (e.g., detectors, drugs, vaccines, and decontamination technologies) to protect the U.S. against these threats.

5.2 Federal Response Plans and Guidance

The National Response Plan, the National Incident Management System, and the National Preparedness Goal are interrelated initiatives seeking a common approach to domestic incident management, including biohazard events.¹⁰⁴ These initiatives are described below. In addition to such initiatives, the Federal government has developed exercises intended to help states,

regions, and local jurisdictions test their capacity to implement guidance.¹⁰⁵ Those exercises intending to test response to biohazard events were discussed in Chapter 3.

5.2.1 National Response Plan (NRP)

The NRP provides the structure and mechanisms to coordinate operations for Incidents of National Significance (major events that require a coordinated and effective response by an appropriate combination of Federal, state, local, tribal, private sector, and nongovernmental entities). The NRP is an overarching structure that addresses all relevant functional areas and all types of incidents. The plan does not substantively address transportation operating during biohazard events. It does discuss the roles of Federal agencies for each functional area. The U.S. DOT has a support role under the following functional areas:

- Information, Intelligence, and Warning;
- International Coordination;
- Border and Transportation Security;
- Infrastructure Protection;
- Emergency Management; and
- Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) Hazard Management.

5.2.2 National Incident Management System (NIMS)

The NIMS provides a consistent framework for entities at all jurisdictional levels to work together to manage incidents. As with the NRP, it covers all stages and types of emergency situations and all functional areas. NIMS includes a core set of guidelines, standards, and protocols for command and management, preparedness, resource management, communications and information management, supporting technologies, and management and maintenance of NIMS. As a result of its breadth, the NIMS also does not address biohazard events and transportation responsibilities in detail.

5.2.3 National Preparedness Goal

The National Preparedness Goal establishes readiness priorities, targets, and metrics in order to define the current and desired level of preparedness. The national preparedness goal discusses planning needs for each of 36 key areas and mentions areas where coordination with transportation will be important. These include areas such as emergency evacuation, isolation and quarantine, information sharing and collaboration, mass prophylaxis and vaccination, medical supplies management and distribution, and medical triage.

5.2.4 Emergency Exercise Guides

In addition to the guidance above, DHS/ODP have also prepared "Emergency Exercise Guides" for discussion-based exercises (workshops, seminars, and tabletops) and for operations-based exercises (drills, functional and full-scale exercises). These guides indicate the types of activities to be performed to address the eight mission areas identified by DHS/ODP and discussed in section 3.1. These guides are intended to support exercises by breaking down the response

process and likely activities to be performed during a range of WMD threats, including biohazards and bioterrorism.

5.3 State Emergency Management Plans

This section discusses typical elements of state emergency operations plans and how they address biological threats. Generally, state-level plans do not consider the transportation role in the context of biohazard events. However, this may change as terrorism response plans become more detailed and robust.

5.3.1 Typical Contents of State Emergency Management Plans

State plans, often prepared by state emergency management agencies, generally follow the structure established in the Federal Response Plan. The Federal Response Plan recently was superseded by the National Response Plan (discussed above), but few states have updated their response plans accordingly. This means, for example, that existing state plans are likely to include fewer emergency support functions and less detailed discussion of terrorism response than the NRP.

State emergency management plans are typically organized around four components:¹⁰⁶

- Mitigation: Steps taken in advance to reduce the potential loss from a hazard;
- Preparedness: Steps taken in advance to facilitate the response and recovery after a hazard event;
- Response: Steps taken during or immediately after a hazard event to save lives and property;
- Recovery: Steps taken to restore the affected areas to their normal status.

In addition, state emergency management plans generally organize the state agencies into emergency support functions (ESFs). Each ESF section generally describes the mission, policies, concept of operations, and responsibilities of the primary agency and any support agencies. The following ESFs, which are outlined in the National Response Plan, cover most of the topics included in state emergency response plans:

- ESF #1 – Transportation
- ESF #2 – Communications
- ESF #3 – Public Works and Engineering
- ESF #4 – Firefighting
- ESF #5 – Emergency Management
- ESF #6 – Mass Care, Housing, and Human Services
- ESF #7 – Resource Support
- ESF #8 – Public Health and Medical Services
- ESF #9 – Urban Search and Rescue
- ESF #10 – Oil and Hazardous Materials Response
- ESF #11 – Agriculture and Natural Resources

- ESF #12 – Energy
- ESF #13 – Public Safety and Security
- ESF #14 – Long-term Community Recovery and Mitigation
- ESF #15 – External Affairs

Several states include additional ESFs, such as Security and Law Enforcement, Military Support, Donations, and Volunteers. State DOTs typically lead for the Transportation ESF and the Public Works and Engineering ESF, and they provide support for a number of other ESFs. Some states that do not have a separate Terrorism Annex within the Emergency Operations Plan may address terrorism response within the 12 core ESFs described above. However, terrorism annexes are increasingly common in such plans.

5.3.2 The Incident Command System

For most emergencies, transportation response, regardless of mode of transportation, will be a support role. To coordinate the effective use of all the available resources, a formalized management structure is used to promote consistency, foster efficiency, and provide direction during a response. The Incident Command System (ICS), which provides that structure, is organized around five major components:

- Command,
- Planning ,
- Operations,
- Logistics, and
- Finance/Administration.

In 2003 the President and DHS announced that the ICS would serve as the national standard for all hazards. The ICS employs a unified command component that is critical for coordinated leadership during major events. The ICS is designed to allow people from other agencies to step into a position and start carrying out its functions quickly by providing position checklists for events such as mass casualties, urban search and rescue, high rise fires, and hazardous material crises. ICS uses a common organizational structure and standardized key management principles for all risk types, making it appropriate to all types of emergencies. ICS and Unified Command are most common in the law enforcement and fire communities, but also have broader applications, e.g., to state DOT incident management programs.

5.3.3 Individual State Plans

Many states have focused on updating emergency management plans and conducting exercises in order to better address terrorism threats, including biohazard events. A recent survey by the National Governors Association suggested that states have focused significant attention on bioterrorism preparedness during the past few years.¹⁰⁷ All responding states said that they had developed plans for distributing vaccination stockpiles and have assessed, or are in the process of assessing, the capabilities of hospitals to handle a surge of patients in the event of an incident. The survey also shows that 95 percent of the responding states have acted to amend policies and laws related to isolation and quarantine practices. In terms of coordinating response plans

between state and local responding agencies, 82 percent had completed this process, while another 13 percent were in progress.

For security reasons, detailed portions of many state emergency management plans are not readily available. Generally, state plans do not provide significant specific mention of biohazard events. They tend to provide general command structures and broad tasks that will require coordination at various stages of emergency events. For example, these state plans rarely address the distinction in medical triage requirements for a biological versus chemical attack. Several examples of state plans are discussed below.

Arizona

Arizona has been active in promoting emergency response coordination through the Arizona Counter Terrorism Information Center. This effort integrates information sources from the Department of Health Services' bioterror alert/notification system with the state DOT's transportation monitoring system. The National Guard and Integrated Justice System are also included in the data integration effort. The state has been proactive in identifying updates needed to the State Emergency Response and Recovery Plan. These updates are delineated in the document, *Securing Arizona A Roadmap for Arizona Homeland Security*.¹⁰⁸

Florida

Florida's Incident Operations Guide¹⁰⁹ integrates all emergency response areas. One chapter (of 20) is devoted to weapons of mass destruction (WMD), but includes little discussion of transportation roles or operations strategies, and includes no discussion relating specifically to biohazards. In general, discussion of transportation roles or operations strategies is limited.

Nebraska

Nebraska's State Emergency Operations Plan¹¹⁰ describes the transportation emergency support function, detailing roles, responsibilities, and equipment needs anticipated from the State Department of Roads during an emergency. A separate terrorism/WMD emergency support function discusses state and Federal responsibilities during a terrorist attack. Here, the State Department of Roads is only mentioned for its responsibility to coordinate with state police in preparing an incident response plan.

New Jersey

A review of the *New Jersey Domestic Security Preparedness Task Force 2003 Annual Report*¹¹¹ identifies a wider range of state DOT activities aimed at detecting and responding to terrorist events. With the exception of surveillance and communications systems, few, if any, of these activities appear to address bioterrorism scenarios.

5.3.4 State DOT Emergency Operations Plans

Some state DOTs have their own Emergency Operations Plans. These are typically focused on surface transportation, addressing specific authorities, conditions and hazards, emergency planning assumptions, concepts of operations, and responsibilities. Many DOTs, for example, have detailed annexes for the following areas:

- Operations center plans (e.g., DOT traffic management center and emergency operations center guidelines);
- Resource management plans (e.g., emergency facilities plans and emergency equipment plans);
- Traffic management plans (e.g., evacuation management plans and incident management plans); and
- Hazard specific plans (e.g., terrorism emergency procedures and various natural disaster emergency procedures).

5.3.5 Other Useful State Guides

A number of guidance documents have been prepared to help state and local governments plan for emergency response to biohazard events. Following are several key examples.

Interim Planning Guide: Improving Local and State Agency Response To Terrorist Incidents Involving Biological Weapons¹¹²

This guide serves both state and local governments with a template to help integrate biological weapons threat considerations into emergency operations plans and standard operating procedures. The template discusses three main actions:

- Continuous surveillance,
- Active investigation, and
- Emergency response.

Within these three actions, the plan details thirteen components, many of which have clear roles for transportation operations, as shown in Table 5-1.

Table 5-1: Emergency Planning Components and the Role of Transportation Operations

Emergency Planning Components	Role of Transportation Operations
Medical Surveillance	Minimal role
Medical Diagnosis	Minimal role
Epidemiological Investigation	Investigating flow of passengers and goods, providing biological sample chain of custody
Criminal Investigation	Investigating flow of passengers and goods, providing biological sample chain of custody
Mass Prophylaxis	Distributing prophylaxis, transporting patients
Residual Hazard Assessment and Mitigation	Minimal role
Control of Affected Area/Population	Restricting mobility by all modes
Modular Emergency Medical System (MEMS)	Maintaining access to MEMS stations
Fatality Management	Transporting bodies
Emergency Management Operations	Managing traffic, providing travel escorts
Resource and Logistic Support	Establish staging areas, developing supply chains
Continuity of Infrastructure	Establish ongoing transportation infrastructure operations plan
Family Support Services	Minimal role

Source: Department of Defense, 2000. *Interim Planning Guide: Improving Local and State Agency Response To Terrorist Incidents Involving Biological Weapons*, prepared in response to the Nunn-Lugar-Domenici Domestic Preparedness Program, September 12. http://www.bioterrorism.slu.edu/bt/key_ref/DOD/bwirp_interim_planning.pdf

This guidance also discusses implementation in terms of the flow of information, need requests, and responsibilities between local, state, and Federal agencies. The guide identifies Federal and likely state leadership for each of the thirteen areas discussed above.

A Guide to Updating Highway Emergency Response Plans for Terrorist Incidents¹¹³

This document, sponsored by the American Association of State Highway and Transportation Officials (AASHTO), points out some key distinguishing response issues for terrorist incidents and addresses how terrorist involvement may change the response relative to typical emergency operations. The guide also suggests considerations for updating internal and external arrangements for responding to terrorist incidents. Detailed checklists are provided for each of the following areas:

- Planning, training, and exercising;
- Roles and responsibilities;
- First response;
- Concept of Operations;
- System surveillance and management;
- Agency communications; and
- Public information.

Within each of these areas, the guide asks critical questions about the existing DOT program area, potential program modifications, and possible procedural approaches to implementing desired program modifications. The guide does not address bioterror threats specifically. Rather, it addresses response plan needs related to nuclear, chemical, and biological threats collectively.

5.4 Local and Regional Plans

State emergency management plans are intended to provide a “blueprint” to guide local response to an emergency, including warning, notification, public information, evacuation, mass care, and shelter. As discussed, any major biohazard event would quickly elevate to a broad geographic concern and would immediately command state and national leadership. However, coordination at the local and regional level would remain vital.

Based on surveys, large metropolitan counties with a population of one million or more are better prepared for biological or chemical terrorism than other counties.¹¹⁴ These areas are more likely to have the following:

- An interagency task force or committee that addresses planning for these types of incidents;
- Plans or standard operating procedures in place that address response to moderate-sized biological or chemical incidents, including communication with other emergency and health care responders;
- Recently exercised response plans for a biological or chemical incident; and
- Plans for disseminating public health information to other emergency and health response organizations.

5.5 Transit Emergency Response Guidance

This section discusses guidance and planning related to transit preparedness and response during biohazard incidents. The discussion covers transit agency response plans, Federal Transit Administration (FTA) guidance, and other guidance related to biohazards' impact on transit systems.

5.5.1 FTA Guidance and Other Overarching Plans and Programs

FTA is involved in a wide range of activities to support transit agencies in enhancing security and emergency response. Much of this activity focuses on trainings and guidance, some of which are described below.

Transit Watch¹¹⁵

This security initiative is designed to raise the awareness of transit employees, riders, and the general public. FTA is encouraging transit agencies to embrace the initiative by adapting the tools, communications, and branding materials for local needs and using the program to strengthen existing safety and security public awareness efforts.

Standard Protocols for Managing Security Incidents Involving Surface Transit Vehicles¹¹⁶

These brief protocols help transit operators and bus dispatch/control center personnel in preparing for, and understanding how, terrorists might attack their system. Transit vehicles are ideal targets for explosives. Although some types of transit vehicles are less optimal targets for chemical or biological attack, in light of the broad scope of the general threat to transit, it is vital that appropriate response procedures be in place to adequately respond to such incidents and minimize their effects. The protocols are mainly focused on the transit vehicle operator. However, the information provided also may apply to transit operations staff in general, including maintenance and service personnel, yard supervisors, and management. The protocols address three areas:

- Prevention – addressing inspection of transit vehicles, as part of a routine maintenance measure, to prevent the placement of an explosive device or hazardous substance.
- Unknown substances and suspicious packages – addressing conditions that should motivate the transit operator to pull over (in the case of buses) or stop the train and evaluate the situation to determine if there is a potential threat to life or health on the vehicle.
- Response – addressing isolation, evacuation, and requests for help and illustrating measures to be taken when responding to a verified or highly suspicious event.

Emergency Preparedness for Transit Terrorism¹¹⁷

This Transportation Research Board (TRB) program promotes the Incident Command System (ICS), a flexible management structure for maximizing communication and coordination with emergency response personnel. This structure departs from routine transit organizational structures and enables the creation of a temporary emergency organization uniquely matched to the requirements of the incident. It allows transit police and operations personnel to work with other emergency responders to establish a common set of incident objectives and a single plan for managing the incident. The guidebook suggests that some transit agencies have trouble

seeing any value in an ICS, in part because routine organizational structures are adequate to manage normal operations and minor emergencies. Lacking experience with large-scale emergencies, they may not appreciate the level of information and exchange that is needed.

Critical Incident Management Guidelines¹¹⁸

This FTA guidance document addresses terrorism response in a general fashion, with some specifics about biological agents and response. The guidelines include four response options:

- non-action (maintain normal service),
- covert search (conduct search without restricting service),
- restricting service (localized closure and evacuation), and
- suspending service (system-wide closure and evacuation).

These guidelines also discuss the evolution of emergency management in transit environments, including a description of local responsibilities, interagency coordination, the incident command system, and emergency procedures. These typical emergency operations plans issues are discussed in the context of several specific disaster response areas, including terrorism. The guidelines discuss detection of biological agents, focusing on the immense challenges and differences from detection of chemical agents. Finally, the document makes several response recommendations, listed below:

- If outside, approach or evacuate upwind of the suspected area.
- If outside, immediately cover all exposed skin surfaces and protect the respiratory system as much as possible, using overcoats, boots, gloves, hats, self-contained breathing systems, and organic vapor respirators.
- If inside and the incident occurs inside, evacuate while minimizing passage through the contaminated area.
- If inside and the incident occurs outside, stay inside, turn off air conditioning, and seal windows and doors with plastic and tape.
- Immediately request emergency assistance and report the incident.
- Provide information on hazards to responding personnel so they can adopt appropriate protective measures.
- Consider decontamination as an immediate first aid need.

The Public Transportation System Security and Emergency Preparedness Planning Guide¹¹⁹

The FTA published this guide in order to help transit agencies plan for and respond to major security threats and emergencies. The guide discusses preparation of a transit Security and Emergency Preparedness Program (SEPP), focusing on management structure, resource issues, and coordination between local and state agencies. It also addresses some specific issues that are critical for biohazard preparedness, including capabilities assessment, training, and evaluation and reduction of vulnerabilities. The guide lists specific response considerations for an actual chemical or biological release, as well as some discussion of technology options. A capabilities assessment worksheet also addresses several issues related to biological hazards, including table-top exercise recommendations, collaboration with other agencies regarding decontamination

equipment, and options for biological response trainings offered by the U.S. Army. This document also lists security contacts at the 35 largest U.S. public transportation systems.

Several additional FTA initiatives also address biological incidents related to transit. These include:

- Standard protocols and guidelines for responding to chemical and biological incidents in rail, tunnel and transit vehicle environments;¹²⁰
- A joint FTA/American Public Transportation Association (APTA) Rail Safety Audit Program that includes response plans, training, and guidance on ventilation systems during emergencies;¹²¹ and
- An FTA Office of Safety and Security assessment of critical asset vulnerabilities. This report considers the most likely threats for both rail and bus systems, including components of the system that are most vulnerable to bioterror attacks.¹²²

5.5.2 Transit Agency Plans

All transit agencies have emergency management plans. These are generally oriented toward moving around problem areas and providing assistance to first responders. In this regard, many of the broad emergency management plans have some application for biohazard events, but they do not address biohazards specifically. However, the 30 largest transit agencies have plans specifically to address WMD. The FTA also has assessed the vulnerabilities of the 37 largest transit systems. These plans and assessments are not readily available.

5.6 Rail Guidelines

The rail industry works on a range of security issues through the Railroad Security Task Force at the Association of American Railroads (AAR). This Task Force has assembled a classified database of railroad assets, vulnerabilities, and risk reduction countermeasures; however, it is unclear to what degree the database addresses biohazards. AAR houses a 24-hour operations center to coordinate industry-wide rail freight security. The center can communicate with all U.S. and Canadian Class 1 carriers, as well as many regional carriers.

In addition, individual railroad companies have developed response plans for a range of terrorist threats. The industry has conducted a number of exercises to assess capabilities for issues such as moving critical recovery materials in response to a terrorist attack and using box cars for evacuation purposes.¹²³

6 Overview of Applicable Emergency Response Models and Tools

There are a variety of existing automated tools to assist with planning and/or responding to a biohazard event, as well as tools that focus more broadly on transportation operations during emergency situations. We briefly review these tools to provide context for a discussion of our options under Task 6. For the purposes of this review, we group these tools into the following four categories:

- *Information sharing tools,*
- *Operations support tools,*
- *Network-based transportation models, and*
- *Biohazard planning support tools.*

6.1 Information Sharing Tools

Information sharing tools enable the sharing of real-time, near real-time, and archived data to support emergency transportation operations. These systems can be used to relay information such as emergency event notification and status, responding agencies at the scene, geographic boundaries of the event, location of facilities and equipment near the affected area, status of traffic conditions in the affected area, identified evacuation routes and detours, identified facility closures and area-wide sequestration plans, and estimates of the impact of the incident on the transportation system.

Examples of such tools include DMIS and E-TEAM, both of which operate a web-based centerpiece that enables the sharing of support tools and data transactions. PB Alert is an alert system to gather, filter, consolidate, and distribute alert messages. Another information sharing tool is CARS (Condition Acquisition and Reporting System), a road reporting system that creates a multi-state database of highway events.

6.2 Operations Support Tools

Operations support tools inform decision-making during emergency events. These types of tools might provide recommendations for initiating evacuations, systems for initiating, tracking, and responding to resource requests, systems for automating the selection of traffic diversions and/or transit service changes, and systems for ensuring that emergency responder transportation needs are relayed to transportation management centers (TMCs) and local authorities. Some also function as information sharing tools.

Several tools of this type have been developed to facilitate the tracking and management of hurricane-related emergencies, including ETIS and HURREVAC. ETIS, for example, is designed to predict evacuation traffic congestion and cross-state travel flows. Other examples of operations support tools were developed for military use, including IRRIS and SENTRY. IRRIS (Intelligent Road/Rail Information Server) is a web- and map-based data clearinghouse with

query functionality that can provide driving directions by route and vehicle type, provide avoidance directions, and can track container shipment by truck, rail, and waterway. SENTRY is a chemical, biological, radiological, and nuclear early warning and decision aid system that integrates remote sensor data, produces dispersion models, sends out alerts, and initiates protective responses.

6.3 Network-Based Transportation Models

A network-based transportation model simulates the operation of a portion of the transportation system. Such tools can be used in planning for emergency response by modeling how the transportation system performs under the challenges of an emergency. Several transportation models that focus specifically on emergency response have been developed. OREMS (Oak Ridge Evacuation Modeling System) is a transportation simulation model targeted to analysis of large-scale emergency evacuations. OREMS supports the identification of evacuation routes, estimation of evacuation times, and development of traffic management strategies, and can be run at the state, regional, city, or corridor level. KLD Associates has a model it calls PCDYNEV (PC-based Dynamic Network Evacuation Planning System). PCDYNEV is a regional simulation model of traffic operations that is used to test and refine plans for an emergency evacuation in response to severe weather or to industrial, chemical or nuclear accidents.

Standard transportation planning and simulation models can also be used for emergency response planning purposes. Four-step travel demand models (e.g., TransCAD, EMME/2, MINUTP, TP+, TranPlan) can be used to model roadway network performance for an entire metropolitan area. CORSIM is a micro-simulation traffic model that can simulate different intersection controls, including freeway ramp metering, different surface geometries, and a variety of traffic flow conditions. TRANSIMS is a broader micro-simulation system that can simulate the movements of each person and vehicle in order to anticipate potential bottlenecks for various scenarios throughout a metropolitan area. Another example is TrEPS, the Traffic Estimation and Prediction System supported by FHWA. TrEPS uses advanced traffic models, surveillance information, historical data, and information from other ITS sub-systems to estimate current traffic conditions and predict consistent emerging conditions.

6.4 Biohazard Emergency Planning Support Tools

Several other computerized tools have been developed to assist in planning and preparing for specific components of a biohazard emergency. One is the Weill/Cornell Bioterrorism and Epidemic Outbreak Response Model (BERM). BERM is a planning tool to help emergency planners understand the logistical and staffing needs of a large-scale prophylaxis campaign. BERM is primarily intended to help hospitals and health systems plan antibiotic dispensing and vaccination campaigns to respond to bioterrorism or large-scale natural disease outbreaks. It is an Excel-based model in which the user inputs the size of the target population, the time frame for the campaign, characteristics of the prophylaxis clinic patient flow, speed of patient processing, and bioterrorism release scenario. In return, the model outputs the number of sites and type of staff required to complete the prophylaxis campaign in the selected time frame.

Work being conducted under NCHRP Project 20-59(19) is focusing on developing a tool intended to assist in identifying unintended consequences of transportation response actions to

biohazard, chemical, radiological, or nuclear exposure situations. This spreadsheet-based tool allows users to select transportation response actions (e.g., shutting down a highway system, closing tunnels and bridges, reducing rail or air service) and then identifies possible unintended (i.e., secondary) consequences of the response. The tool also provides information on anticipated timing of impacts and potential solutions.

The Multimodal Transportation and Bioterrorism Defense (MMTB) Model is intended to estimate the patterns of travelers subjected to a bioterrorism release and the corresponding spread of disease. The model allows users to define a scenario of a biohazard release in a transportation network, including the type of pathogen, type of transporter (e.g., aircraft), and hub characteristics (e.g., arrival and departure frequencies). The model estimates the dispersion of infected passengers throughout the network and the corresponding impacts. The model is currently under development by researchers at Embry-Riddle Aeronautical University.

7 Conclusions

This section draws some conclusions from the literature review that bear on one or more of the remaining project tasks.

Biohazards can differ greatly in their environmental persistence, contagiousness, and incubation period. These differences have significant implications for how a biohazard event might unfold, and the role of transportation in responding to the event.

- Many bioagents are relatively unstable in the open environment, meaning they do not survive long after release. *Bacillus anthracis* (anthrax) is unusual in that it is a bacterial spore and extremely stable. To be effective as a weapon, most other bioagents must be dispersed in aerosolized form that results in rapid human exposure.
- Among the Category A biohazards, only two cause diseases that are highly contagious (plague and smallpox). Most other Category A biohazards diseases (including anthrax, botulism, and tularemia) cannot be transmitted between humans, and therefore do not warrant quarantine to prevent human-to-human spread of disease. (Quarantine or isolation may be warranted in order to ensure proper medical treatment or decontamination, or to prevent human exposure to other sources of the bioagent).
- The incubation period of bioagents can vary from a few hours to more than a week. Humans exposed to *clostridium botulinum*, for example, will typically show signs of botulism within 12 to 36 hours. In contrast, smallpox typically does not appear until 12 to 14 days after exposure to the variola major virus.

Deliberate release of a biohazard directed at humans is generally recognized to be the type of biohazard event that poses the greatest risk to human health and national security. Other types of biohazard events (e.g., agroterrorism, accidental release, natural occurrence) are generally recognized to pose less risk, although these events still warrant emergency response preparation. The nature of a deliberate release of a biohazard (overt vs. covert) greatly affects the response and the role of transportation agencies.

- An overt release might be identified through previous intelligence, post-event claim of responsibility, or direct evidence (e.g., powder residue, equipment used to release the bioagent) gathered at the release site. The response in an overt situation could be immediate, increasing the chances of limiting those exposed. First responders would be those traditionally involved in an emergency – police, firefighters, and Emergency Medical Services (EMS) personnel.
- A covert release is generally considered a more likely biohazard event, and potentially has far greater consequences. Due to the delayed onset of most diseases caused by bioagents, there would likely be no indication of foul play until days or even weeks after the initial release. Exposed individuals likely would begin to report generic symptoms accompanied by a fever to healthcare personnel at local hospital and medical centers. Delay would occur before the disease is diagnosed and then confirmed. All the while, those initially infected may be spreading the disease to others, potentially leading to a second generation outbreak of the disease.

Our review of 19 past biohazard exercises shows that most are one of two types: (1) aerosolized release of a bioagent in a crowded shopping mall or (2) aerosolized release of a bioagent at a heavily attended sporting event. In these exercise scenarios, air ventilation systems often are assumed to increase dissemination, extending the reach of an aerosolized bioagent to expose as many people as possible within an enclosed building or subway station. In most of the exercise scenarios, identification of the disease occurs at least several days after the initial release.

The role of transportation in a biohazard event varies greatly depending on the characteristics of the event. The transportation system can function to spread a deliberately released bioagent, or the system itself may be the target of a deliberate release. Transportation systems can also play a role in the application of technology for detection and identification of a bioagent. Our project is focused primarily on the role of transportation in responding to a biohazard. These roles can include the following:

- Restricted mobility to prevent disease spread (e.g., closure of roadways, airports, seaports, or rail lines to prevent travel by infected persons; establishment of checkpoints for decontamination);
- Restricted access to prevent exposure (e.g., closure of roadways or rail lines to prevent exposure to contaminated areas, while maintaining mobility around the area);
- Rerouting of ongoing transportation demands around contaminated areas;
- Delivery of prophylaxis (e.g., obtaining SNS packages; local distribution of antibiotics or vaccines);
- Provision of additional medical support (e.g., emergency transportation to hospitals; transport of infected persons to an area that can handle them; transport of individuals who cannot drive); and
- Provision of supplies to quarantine areas (e.g., food and supplies to quarantined households; critical supplies to maintain urban support systems such as drinking water).

The transportation roles discussed above require complex coordination that will benefit from supporting emergency response tools. This literature review (and appendices) summarizes a number of the tools that are currently available and under development that may play a role in emergency response during biohazard situations. Tools range from generic information sharing tools that track assets and emergency contacts, to targeted biohazard planning support tools that provide specific consideration of secondary impacts of quarantine, and prophylaxis distribution approaches. Existing guidance and tools provide a helpful foundation for a decision support tool that will help transportation operations staff respond effectively to biohazard events.

Appendix A: Bioagents Background Information Table

Causative Agent	Disease Caused	Target Organism	Environmental Persistence	Infectivity (ID ₅₀) (# of organisms required to cause infection)	Contagiousness (ease of human-to-human transmission)	Exposure Route
Category A						
Bacteria Spore						
<i>Bacillus anthracis</i>	Anthrax	Human, Animals	Extremely stable (>40 years) ^{1, 33, 37}	Moderate (Ingestion/Direct contact) to High (Inhalation: 8,000 – 50,000 spores) ^{1, 24, 37}	None ^{1, 37}	Inhalation, ingestion, direct contact (does not require open wound, transmittable through skin) ^{2, 33}
Bacteria						
<i>Clostridium botulinum</i>	Botulism	Human	Unstable ^{34, 35}	Low (0.001 µg/kg) ^{1, 37}	None ^{34, 35, 37}	Direct contact (open wound) ^{2, 34}
<i>Francisella tularensis</i>	Tularemia	Human	Very stable (months) ¹	Low (10 – 50 organisms) ^{1, 37, 41}	None ^{1, 37, 41}	Inhalation, ingestion, direct contact (insect bite; skin contact with infected animal tissues or fluids or with contaminated water, food, or soil) ^{2, 41}
<i>Yersinia pestis</i>	Plague	Human	Pneumonic: Very stable (up to 1 year in soil, 270 days in live tissue) ^{1, 37} Bubonic, septicemic: Stable ¹	Pneumonic: Moderate (100 – 500 organisms) ^{1, 37} Bubonic, Septicemic: Low to Moderate (10 – 100 organisms) ¹	Pneumonic: High; ³⁷ Bubonic, Septicemic: None ^{2, 39}	Pneumonic: Inhalation; Bubonic, Septicemic: Direct contact (flea/rodent bite, open wound) ^{2, 38}
Biological Toxin						
<i>Clostridium botulinum</i>	Botulism	Human, Animals	Stable (days to weeks) ^{1, 36, 37}	Low to Moderate ¹	None ¹	Inhalation, ingestion ^{2, 36}
Virus						
Arenaviruses (e.g., Lassa, Machupo)	Viral hemorrhagic fevers (VHFs)	Human, Animals	Relatively unstable, ^{1, 37} except as an aerosol when it is Stable ⁴²	Very low to Low (1-10 organisms) ^{1, 37}	Moderate ^{1, 37}	Inhalation (rodent excreta or human respiratory droplets); ingestion (food contaminated with rodent excreta); direct contact (rodent excreta via open wound, mucous membranes or infected human body fluids) ^{42, 43}
Bunyaviruses (e.g., Rift Valley fever, Hantaviruses)						Direct contact (mosquito/tick bite; infected animal tissues); inhalation (aerosol from infected animal carcasses); ingestion (contaminated raw animal milk) ^{42, 43}
Filoviruses (e.g., Ebola, Marburg)						Direct contact (human or animal tissues or bodily fluids); injection; inhalation ^{42, 43}
Flaviviruses (Dengue)						Direct contact (mosquito/tick bites) ^{42, 43}

Causative Agent	Disease Caused	Target Organism	Environmental Persistence	Infectivity (ID ₅₀) (# of organisms required to cause infection)	Contagiousness (ease of human-to-human transmission)	Exposure Route
Virus (Continued)						
Variola major	Smallpox	Human	Very stable (as an aerosol) ^{1, 37, 40}	Low to Moderate (10 – 100 organisms) ^{1, 37}	High ^{1, 40}	Inhalation, direct contact (does not require open wound, transmittable through skin, contact with bedding/clothes) ^{2, 33}
Category B						
Bacteria						
<i>Brucella</i> species	Brucellosis	Human, Animals	Very stable (wet soil, food) ^{a 37}	Low to Moderate (10 – 100 organisms) ^{4, 37}	None ^{3, 37}	Inhalation, ingestion, direct contact (open wound) ²
<i>Burkholderia mallei</i>	Glanders	Humans, Animals	Moderately stable (reported to survive up to 4 weeks in water) ²³	Unknown and probably varies due to host resistance ²³	Very low ^{10, 23}	Inhalation, ingestion, direct contact (open wound) ^{10, 23}
<i>Burkholderia pseudomallei</i>	Melioidosis	Humans, Animals	Stable to Very stable (soil and water in tropical climates) ²³	Unknown and probably varies due to host resistance ²³	Very low ^{10, 23}	Inhalation, ingestion, direct contact (open wound) ^{10, 23}
<i>Chlamydia psittaci</i>	Psittacosis	Humans, Animals	Stable ²⁴	Moderate ²⁴	Very low ¹¹	Inhalation, direct contact (mouth-beak) ¹¹
<i>Coxiella burnetii</i>	Q fever	Humans, Animals	Very stable (months) ^{2, 37}	Very low to Low (1 – 10 organisms) ^{2, 37}	Very low to Low ^{2, 37}	Inhalation, ingestion, direct contact (tick bites) ²
<i>Cryptosporidium parvum</i>	Cryptosporidiosis	Humans, Animals	Stable ^{c, 17, 18, 19}	Low to High (10 – 1,000 organisms) ¹⁷	Very high ^{17, 18, 19}	Ingestion ¹⁷
<i>Escherichia coli</i> O157:H7	<i>E. coli</i> O157:H7 infection	Humans, Animals	Moderately Stable (water) to Stable (food); Increasing resistance to antibiotics ^{22, 24}	Very low to Low (estimated)	High in poorly sanitized areas; otherwise, low ²	Ingestion ²
<i>Rickettsia prowazekii</i>	Typhus fever	Humans	Not very stable (susceptible to moist/dry heat ^b) to Moderately stable (weeks) ^{16, 24}	Low (<10 organisms) ¹⁶	None ¹⁵	Direct contact (lice, flea bites), inhalation ^{14, 16}
<i>Salmonella</i>	Salmonellosis	Humans, Animals	Moderately Stable to Stable, Increasing resistance to antibiotics) ^{5, 22}	Very high (1 million – 10 million organisms) ²⁰	High in poorly sanitized areas; otherwise, low ²	Ingestion ²
<i>Salmonella</i> Typhi	Typhoid fever	Humans	Moderately Stable to Stable; Increasing resistance to antibiotics) ^{21, 22}	High to Very high (1,000 to 1 million) ²¹	High in poorly sanitized areas; otherwise, low ²	Ingestion ²

Causative Agent	Disease Caused	Target Organism	Environmental Persistence	Infectivity (ID ₅₀) (# of organisms required to cause infection)	Contagiousness (ease of human-to-human transmission)	Exposure Route
<i>Shigella</i>	Shigellosis	Humans	Moderately Stable to Stable; Increasing resistance to antibiotics) ^{2, 22}	Moderate (as low as 180 organisms) ⁷	High in poorly sanitized areas; otherwise, low ²	Ingestion ²
<i>Vibrio cholerae</i>	Cholera	Humans	Unstable (aerosols and pure water); otherwise, Moderately stable to Stable (polluted water); Increasing resistance to antibiotics ^{2, 9, 22, 24}	High to Very high (1,000 – 1 million organisms with water; 100-10,000 organisms with food) ⁹	High in poorly sanitized areas; otherwise, low ²	Ingestion ²
Biological Toxin						
<i>Clostridium perfringens</i>	Epsilon	Humans, Animals	Stable ¹²	High (>1 billion cells) ¹²	None ¹²	Ingestion ¹²
<i>Ricinus communis</i> (castor bean)	Ricin	Human, Animals	Stable to Very stable (not affected by temperature extremes) ^{1,2}	Low to Moderate (500 micrograms [µg] is lethal if inhaled/injected) ¹	None ¹	Inhalation, ingestion, injection, direct contact (via skin or eye) ²
<i>Staphylococcus aureus</i>	Staphylococcal enterotoxin B	Humans	Stable to Very stable ^{d, 13, 24}	Very low to Low (0.0004 µg/kg) ¹³	None ¹³	Inhalation ¹³
Virus						
<i>Alphavirus</i>	Eastern equine encephalitis (EEE)	Humans, Animals	Very unstable (does not survive outside host) ³²	Unknown ³²	None ²	Inhalation, direct contact (mosquito bite) ^{2, 30}
<i>Alphavirus</i>	Venezuelan equine encephalitis (VEE)	Humans, Animals	Relatively unstable, ³⁷ Stable (when aerosolized and in dried blood and exudates) ³¹	Low to Moderate (10 – 100 organisms) ³⁷	Low ³⁷	Inhalation, direct contact (mosquito bite) ^{2, 30}
<i>Alphavirus</i>	Western equine encephalitis (WEE)	Humans, Animals	Very unstable (does not survive outside host) ³²	Unknown ³²	None ²	Inhalation, direct contact (mosquito bite) ^{2, 30}
Category C						
Virus						
Hantavirus	Hantavirus pulmonary syndrome (HPS)	Humans, Animals	Low to Moderate (days) ²⁷	Unknown ^{27, 28}	None ²⁷	Inhalation, ingestion, direct contact (rodent bite) ²⁷
Megamyxovirus	Nipah virus	Humans, Animals	Unknown ²⁶	Unknown ²⁶	None ²⁶	Not yet determined, but involves direct contact with pigs ²⁶
Not Categorized						
Virus						
Foot-and-Mouth Virus	Foot-and-Mouth Disease (FMD)	Animals	Very stable (up to 1 month) ^{1, 29}	Low ¹	High ¹	Ingestion, direct contact ²⁹

Notes:

^a Under select conditions (e.g., darkness, cool temperatures, high CO₂), persistence up to 2 years is documented.³

^b Moist heat at 250°F (121°C) for ≥ 15 minutes; dry heat at 320-338°F (160-170°C) for ≥ 1 hour

^c Due to protective outer shell, it is resistant to harsh conditions, including chlorine used to treat water, but susceptible to drying and UV light^{17, 18, 19}

^d Water soluble, very resistant to temperature fluctuations, resistant to boiling for several minutes, can be freeze-dried^{13, 24}

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Appendix B: Biological Agents Treatment Table

Causative Agent	Disease Caused	Target	Incubation Period	Medical Treatment ^a		Fatality Rate ^b
				Vaccine	Post-Infection Treatment	
Category A						
Bacteria Spores						
<i>Bacillus anthracis</i>	Anthrax	Human, Animals	Cutaneous: <1 day; Gastrointestinal: 1 day – 2 months; Inhalational: 1 – 42 days ²	anthrax vaccine adsorbed (AVA) produced by Bioport (military use only) ¹	Antibiotics: Penicillin, Doxycycline, Amoxicillin, Ciprofloxacin; Supportive Care ^{1,2}	Cutaneous: <1% (treated) – 20% (untreated); Gastrointestinal: 25% – 60% (estimate, treated); Inhalational: >75% (treated) ²
Bacteria						
<i>Clostridium botulinum</i>	Botulism	Human	6 hours – 2 weeks (typically 12 – 36 hours) ²	DOD pentavalent toxoid for serotypes A – E ¹	Antibiotics: DOD heptavalent equine despeciated antitoxin for serotypes A – G, CDC trivalent equine antitoxin for serotypes A, B, E; Supportive Care ^{1, 34}	5% ²
<i>Francisella tularensis</i>	Tularemia	Human	1 – 14 days (typically 3-5) ²	Live attenuated vaccine for high risk workers; Other vaccine under review by the FDA ^{2, 40}	Antibiotics: Streptomycin, Gentamicin, Tetracyclines, Chloramphenicol, Ciprofloxacin, Doxycycline ^{1,2}	<1% (treated); 5% - 30% (untreated) ³⁰
<i>Yersinia pestis</i>	Plague	Human	Pneumonic: 1 – 6 days (typically 2 – 4 days); ³⁷ Bubonic: 2 – 10 days (typically within 6 days), ^{2, 36, 37} Septicemic: Usually develops after bubonic plague ³⁷	No longer available ¹	Antibiotics: Steptomycin, Gentamicin, Tetracyclines, Chloramphenicol, Ciprofloxacin, Doxycycline, Co-trimoxazole ^{1,2, 35}	Pneumonic: 100% (untreated in first 24 hours); Bubonic: 1-15% (treated), 40-60% (untreated); Septicemic: 40% (treated), 100% (untreated) ³⁵
Biological Toxins						
<i>Clostridium botulinum</i>	Botulism	Human, Animals	6 hours – 2 weeks (most commonly 12 – 36 hours) ²	DOD pentavalent toxoid for serotypes A – E ¹	Antibiotics: DOD heptavalent equine despeciated antitoxin for serotypes A – G, CDC trivalent equine antitoxin for serotypes A, B, E ¹	5% ²

Causative Agent	Disease Caused	Target	Incubation Period	Medical Treatment ^a		Fatality Rate ^b
				Vaccine	Post-Infection Treatment	
Viruses						
Arenaviruses (e.g., Lassa, Machupo)	Viral hemorrhagic fevers (VHFs)	Human, Animals	2-21 days (typically 5 – 10 days) ^{2, 29}	Licensed vaccine for yellow fever; Experimental vaccines for Argentine hemorrhagic fever (AHV), Rift Valley fever virus (RVFV), Hantaan virus, and dengue virus; ³⁸ Lassa fever virus under development by CDC ⁴¹	Ribavirin (Lassa fever, hemorrhagic fever with renal syndrome [HFRS]), AHF; Passive antibody for AHF, Bolivian hemorrhagic fever (BHF), Lassa fever, and Crimean-Congo hemorrhagic fever (CCHF); Convalescent-phase plasma for AHF; Supportive care ^{1, 2, 38}	<1% - 90% ^{29, 39}
Bunyaviruses (e.g., Rift Valley fever, Hantaviruses)						
Filoviruses (e.g., Ebola, Marburg)						
Flaviviruses (Yellow fever, Dengue)						
Variola major	Smallpox	Human	7-17 days (typically 12 – 14 days) ²	Wyeth calf lymph vaccinia vaccine ¹	Antibiotics: Vaccinia immune globulin, Cidofovir; Supportive care ^{1, 2}	30% (some strains, flat and hemorrhagic, are almost always fatal) ²
Category B						
Bacteria						
<i>Brucella</i> species	Brucellosis	Human, Animals	3 – 60 days (shorter for inhalation exposure than ingestion) ³	None ¹	Antibiotics: Doxycycline, Rifampin, Streptomycin, Gentamicin, Ciprofloxacin, Penicillin, Tetracycline ^{1, 3}	<2% ²
<i>Burkholderia mallei</i>	Glanders	Humans, Animals	Direct contact: 1 – 5 days; Inhalation: 10 – 14 days ⁹	None ⁹	Antibiotics: no studies exist, but likely similar to those used for Melioidosis; post-exposure prophylaxis can be tried with trimethoprim/sulfamethoxazole; Supportive care ^{1, 9, 20}	Unknown (only 2 reported cases of the disease) ²⁰
<i>Burkholderia pseudomallei</i>	Melioidosis	Humans, Animals	Direct contact: 1 – 5 days; Inhalation: 10 days – many months (typically 10 – 14 days) ⁹	None ⁹	Antibiotics: Ceftazidime, Imipenem/meropenem, Ciprofloxacin, Doxycycline, Cotrimoxazole, Chloramphenicol, Co-amoxiclav; Supportive care ^{9, 20, 21}	4% - 5% (localized); 90% (with septicemia in chronically ill patients [e.g., HIV, diabetes]) ^{9, 20}
<i>Chlamydia psittaci</i>	Psittacosis	Humans, Animals	5 – 14 days ¹⁰	None ¹⁰	Antibiotics: Tetracycline, Doxycycline, Erythromycin, Chloramphenicol ¹⁰	<1% (treated); 15% - 20% (untreated) ¹⁰
<i>Coxiella burnetii</i>	Q fever	Humans, Animals	10 – 40 days (typically 2 – 3 weeks) ^{2, 34}	None commercially available in U.S.; Vaccine in use in occupational settings in Australia ²	Antibiotics: Doxycycline, Tetracycline, Quinolones, Chloroquine ²	1% - 2%, most recover within several months without treatment ²

Causative Agent	Disease Caused	Target	Incubation Period	Medical Treatment ^a		Fatality Rate ^b
				Vaccine	Post-Infection Treatment	
<i>Cryptosporidium parvum</i>	Cryptosporidiosis	Humans	2 – 28 days (typically 7-10 days) ^{16, 18}	None ^{16, 17, 18}	Antibiotics (none proven effective, especially not in those with AIDS): Paromomycin, Azithromycin, Nitazoxanide; Anti-diarrheal agents used for symptomatic relief include: Loperamide hydrochloride (Imodium), Diphenoxylate and atropine (Lomotil); Anti-retroviral therapy (for those with AIDS) ^{16, 17, 18}	>50% (in those with AIDS); otherwise rarely fatal ^{16, 17}
<i>Escherichia coli</i> O157:H7	<i>E. coli</i> O157:H7 infection	Humans, Animals	Varies, depending on infection	None	Antibiotics: varies depending on infection; Supportive care (rehydration) ⁷	<1%, most recover without treatment in 5 – 10 days; 3% - 5% (intensive care with complications [hemolytic uremic syndrome]) ²
<i>Rickettsia prowazekii</i>	Typhus fever	Humans	1 – 2 weeks (typically 12 days) ^{13, 15}	None; Live vaccine from attenuated strain E shows promise ^{13, 15}	Antibiotics: Doxycycline, Chloramphenicol, Tetracycline ^{13, 14}	3% - 4% (treated); 20% - 60% (untreated) ¹³
<i>Salmonella</i>	Salmonellosis	Humans, Animals	12 – 72 hours ²	None ²	Antibiotics (only for severe case that spreads from the intestines): Ampicillin, Gentamicin, Trimethoprim/Sulfamethoxazole, Ciprofloxacin; Supportive care (rehydration) ²	5.8% (0 -1 years), 2% (1 –50 years), 15% (>50%) ¹⁹
<i>Salmonella</i> Typhi	Typhoid fever	Humans	3 days – 3 months (typically 1 – 2 weeks) ⁴	Vivotif Berna (Ty21a); Vi capsular polysaccharide (ViCPS) (but neither is 100% effective) ²	Antibiotics: Ampicillin, Trimethoprim/Sulfamethoxazole, Ciprofloxacin, Chloramphenicol; Supportive care (rehydration) ^{2, 4}	<1% (treated), 12% – 30% (untreated in developing countries) ^{2, 5}
<i>Shigella</i>	Shigellosis	Humans	1 – 2 days ²	None	Antibiotics (only for advanced/more serious cases): Ampicillin, Trimethoprim/sulfamethoxazole, Nalidixic acid, Ciprofloxacin; Supportive care (rehydration) ^{2, 6}	<1%, most recover in 5 – 7 days; 5% - 15% (untreated in developing countries); >50% (with complications) ^{2, 6}

Causative Agent	Disease Caused	Target	Incubation Period	Medical Treatment*		Fatality Rate ⁺
				Vaccine	Post-Infection Treatment	
<i>Vibrio cholerae</i>	Cholera	Humans	24 – 48 hours ⁸	Wyeth-Ayerst vaccine discontinued; CVD 103-HgR and WC/rBS are licensed and available in other countries (but are not 100% effective and have side effects, not available in U.S.) ^{2,9}	Antibiotics: Tetracycline, Doxycycline, Ciprofloxacin, Erythromycin, Norfloxacin, Trimethoprim/Sulfamethoxazole, Furazolidone, Quinolones; Supportive care (rehydration) ^{1,2}	<1% (with rehydration); 20% - 25% (untreated in developing countries) ²
Biological Toxins						
<i>Clostridium perfringens</i>	Epsilon	Human, Animals	8 – 22 hours ¹¹	None ¹¹	Supportive care ¹¹	Most common form is rarely fatal, most recover within 24 hours; Necrotic enteritis is often fatal
<i>Ricinus communis</i> (castor bean)	Ricin	Human, Animals	2-24 hours (Inhalation: <8 hours, Ingestion: <6 hours) ¹	None ¹	Supportive care ¹	85% ^{2, 31}
<i>Staphylococcus aureus</i>	Staphylococcal enterotoxin B	Humans	1 – 18 hours (typically 1 – 8 hours) ¹²	None ^{1, 12}	Supportive care ¹²	Rarely fatal, most recover within 8 – 24 hours ¹²
Virus						
Alphavirus	Eastern equine encephalitis (EEE)	Humans, Animals	4 – 10 days ²⁴	Investigational vaccines available to laboratory workers ³³	Supportive care ²	35% – 70% ^{2, 23}
Alphavirus	Venezuelan equine encephalitis (VEE)	Humans, Animals	2 – 6 days ³²	TC-83 (used to protect laboratory and field workers) ²	Supportive care ²	0.4% ²²
Alphavirus	Western equine encephalitis (WEE)	Humans, Animals	5 – 10 days ³²	Investigational vaccines available to laboratory workers ³³	Supportive care ²	10% ²²
Category C						
Viruses						
Hantavirus	Hantavirus pulmonary syndrome (HPS)	Humans, Animals	1 – 5 weeks (typically 2 – 3 weeks) ^{26, 27}	None ²⁶	Supportive care ²⁶	38% ²⁷
Megamylxovirus	Nipah virus	Humans, Animals	4 – 18 days ²⁵	None ²⁵	Ribavirin (in vitro); Supportive care ²⁵	50% ²⁵

Causative Agent	Disease Caused	Target	Incubation Period	Medical Treatment [*]		Fatality Rate ⁺
				Vaccine	Post-Infection Treatment	
Not Categorized						
Viruses						
Foot-and-Mouth Virus	Foot-and-Mouth Disease (FMD)	Animals	1 – 14 days ^{1, 28}	Multiple for the many types and sub-types ²⁸	Supportive Care ¹	Low ²⁸

Notes:

^a Medical treatment includes those vaccines and antibiotics available in the U.S.

^b Fatality rates are based on actual cases in or estimates made for the U.S and are for treated cases, unless otherwise noted.

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Appendix C: Examples of Agroterrorism Agents

Animal disease	Disease Agent or Toxin
African horse sickness	Anthrax (<i>Bacillus anthracis</i>)
African swine fever	Botulinum neurotoxins
Akabane	Botulinum neurotoxin-producing species of <i>Clostridium</i>
Avian influenza (highly pathogenic)	
Bluetongue (exotic)	Brucellosis of cattle (<i>Brucella abortus</i>)
Bovine spongiform encephalopathy	Brucellosis of sheep (<i>Brucella melitensis</i>)
Camel pox	Brucellosis of pigs (<i>Brucella suis</i>)
Classical swine fever	Glanders (<i>Burkholderia mallei</i>)
Contagious caprine pleuropneumonia	Melioidosis (<i>Burkholderia pseudomallei</i>)
Contagious bovine pleuropneumonia	Botulism (<i>Clostridium botulinum</i>)
Foot-and-mouth disease (FMD)	<i>Clostridium perfringens</i> epsilon toxin
Goat pox (Valley fever)	<i>Coccidioides immitis</i>
Heartwater (<i>Cowdria ruminantium</i>)	Q fever (<i>Coxiella burnetii</i>)
Japanese encephalitis	Eastern equine encephalitis
Lumpy skin disease	Tularemia (<i>Francisella tularensis</i>)
Malignant catarrhal fever	Hendra virus (of horses)
Menangle virus	Nipah virus (of pigs)
Newcastle disease (exotic)	Rift Valley fever
Peste des petits ruminants	Shigatoxin
Rinderpest	Staphylococcal enterotoxins
Sheep pox	T-2 toxin
Swine vesicular disease	Venezuelan equine encephalitis
Vascular stomatitis	

Source: 9 CFR 121.3(b) and (d), supplemented with common disease names as provided in "Agroterrorism: Threats and Preparedness," Congressional Research Service, Library of Congress, August, 2004.

Plant Disease	Disease Causing Agent
Citrus greening	<i>Liberobacter africanus</i> , <i>L. asiaticus</i>
Philippine downy mildew (of corn)	<i>Peronosclerospora philippinensis</i>
Soybean rust	<i>Phakopsora pachyrhizi</i>
Plum pox (of stone fruits)	Plum pox potyvirus
Bacterial wilt, brown rot (of potato)	<i>Ralstonia solanacearum</i> , race 3, biovar 2
Brown stripe downy mildew (of corn)	<i>Sclerophthora rayssiae</i> var. <i>zeae</i>
Potato wart or potato canker	<i>Synchytrium endobioticum</i>
Bacterial leaf streak (of rice)	<i>Xanthomonas oryzae</i> pv. <i>oryzicola</i>
Citrus variegated chlorosis	<i>Xylella fastidiosa</i>

Source: 7 CFR 331.3(a), supplemented with common disease names as provided in "Agroterrorism: Threats and Preparedness," Congressional Research Service, Library of Congress, August, 2004.

Appendix D: Sample of Biohazard Exercise Scenarios

Note: Some state homeland security/emergency response websites mention bioterrorism response exercises; however, the scenarios are generic with no specific mention of a bioagent or stated event sequence. Many exercises are held to execute the distribution of Strategic National Stockpile (SNS) supplies of vaccines. Examples can be found at the following websites:

- http://www.bens.org/what_bio_AAR.html
- <http://www.michigan.gov/homeland/0,1607,7-173-23616-69379--,00.html>
- <http://www.wakegov.com/news/111303bioterrorism.htm>

Smallpox (*Variola major virus*)

*Scenario 1: Atlantic Storm*¹²⁴

Scenario Description

On the eve of a summit of international leaders to discuss trans-Atlantic security, leaders learn that smallpox has been simultaneously released in several European cities, followed by releases in the U.S. a couple of days later. A dry powder form of smallpox was dispensed via a small fire extinguisher-sized dispenser (dispensers and sprayers are commercially available) hidden in backpacks by terrorists walking through target locations for several hours during peak occupancy periods. A summary of the trans-Atlantic attacks is listed in the Table D-1 below.

Table D-1: Summary of Smallpox Releases as Part of Atlantic Storm Exercise

Target Location	Release Date	Number of Infected
Frankfurt Airport, Germany	January 2	16,000
Rotterdam Metro System, Netherlands	January 2	8,000
Warsaw Metro, Poland	January 2	12,000
LAX	January 4	16,000
Penn Station, NYC	January 4	24,000
Grand Bazaar, Istanbul, Turkey	January 1	8,000
Total Infected		76,000

The developers (not necessarily the participants) of the exercise made the following assumptions:

- Symptoms began as early as 7 days after infection;
- Transmission rate from 1st generation of cases was 1:3;
- 2nd generation transmission rate was 1:0.25 (given to-be-implemented disease control measures after identification of the smallpox);
- Initial diagnoses in Europe occurred on January 13 (10-11 days after infection); and
- Mass vaccination would begin within days of the January 14th summit.

Actual exercise revealed that leaders considered two vaccination options:

- (1) “ring” vaccination, i.e., vaccinating those who had been in contact with patients and health care workers; or
- (2) mass vaccination of the whole population.

The following issues were raised during the exercise:

- Willingness and political feasibility of countries with sufficient vaccine stockpile to vaccinate entire population to provide additional supplies to countries that did not have sufficient supply;
- Whether to close borders and/or quarantine cities; and
- How to limit the movement of people and goods.

Transportation’s Role

No immediate response due to late detection and identification; Air transport of vaccine from countries with sufficient supply to those without a sufficient supply; Distribution of vaccine; Restricting travel to/from affected cities, states, countries.

Scenario 2: Dark Winter Smallpox Exercise¹²⁵

Scenario

A tabletop exercise was conducted that simulated a covert smallpox attack on the U.S. and the response of the National Security Council (NSC) over an approximately two-week period. The developers (not necessarily the participants) of the exercise made the following assumptions:

- 3,000 people were infected during three simultaneous attacks in three separate shopping malls in Oklahoma City, Philadelphia, and Atlanta; and
- A 1:10 transmission rate for all generations (exercise concludes during the 2nd generation of cases).

The NSC (i.e., the exercise participants) learn of the attack on December 9, 2002. Initial exposure was determined to have occurred approximately December 1, given smallpox’s 9- to 17-day incubation period. The NSC considers three policy options and selects the first option (ring vaccination):

- Ring vaccination: vaccine distributed to each of the three states to vaccinate patient contacts and essential health care personnel, with some doses set aside for the DoD;
- Combination ring/mass vaccination #1: vaccine distributed to each of three states so that all residents of the affected cities could be vaccinated, as well as patient contacts and essential personnel, with same dosage set aside for DoD; or
- Combination ring/mass vaccination #2: vaccine distributed to each of the three states to vaccinate residents of the affected cities, with same dosage set aside for DoD, plus a pre-determined dosage given to rest of the 47 unaffected states to use at their discretion.

Six days after the NSC learns of the smallpox release, the epidemic has spread to Canada, Mexico, and the UK. On the same day the international epidemic is determined, the shopping malls are pinpointed as the release sites. Select international borders are closed to trade and travelers, which has the undesirable consequence of resulting in food shortages in affected states.

Schools are now closed nationwide, and public gatherings are limited in affected states, while some other states limit travel and nonessential gatherings. Three U.S. drug companies agree to produce a new vaccine, with first delivery in five weeks, and Russia offers an additional 4 million doses, as the U.S. stockpile dwindles.

Thirteen days after learning of the release, a total of 11 countries (including the U.S.) have reported isolated cases, presumably from international travelers from the U.S. Vaccine supplies are now depleted, and new vaccine won't be ready for four weeks. All states have restricted nonessential travel, food shortages are growing, and the economy is down. Residents have fled the initial three affected cities and continue to flee cities where new cases are reported. Canada and Mexico have closed their borders to the U.S., and the public is demanding mandatory isolation of smallpox victims and those in contact with them, but identification of all contacts is not possible.

The scenario ends when an anonymous letter demands removal of U.S. forces in Saudi Arabia and warships from the Persian Gulf. Failure to comply will result in new attacks of smallpox, as well as anthrax and plague, on the U.S. The responsible agent for distributing the smallpox is not confirmed, but believed to be tied to Iraq.

Transportation's Role

No immediate response due to late detection and identification; Distribution of vaccine; Restricting travel to/from affected cities, states, countries; Distribution of food and necessities to minimize shortages.

Scenario 3: An Intentional Smallpox Epidemic at a University¹²⁶

Scenario

A terrorist group releases smallpox in aerosol form at a local university in the northeastern U.S. First reported symptoms appear 11 days after release. Fourteen days after the release, the first symptomatic patient returns with more symptoms to the ER where he originally sought treatment and is treated for chicken pox and isolated within the hospital. Fifteen days after the release, samples are sent to the CDC, which identifies smallpox. Authorities consider a full quarantine of the city (restrict air and rail traffic), but decide this is too drastic. Ring vaccination is used. By day 16, cases have been reported in a nearby state. Twenty-one days after the release, the second generation of cases is identified by the CDC, and smallpox has spread to eight other states and internationally in isolated cases. Vaccine is distributed to affected states, but is only enough to vaccinate approximately 15 percent of the affected population. By day 59 (third generation), the vaccine supplies are depleted. Sixty days after release, the fourth generation begins, and the scenario is ended with no end to transmission of the disease in sight.

Transportation's Role

No immediate response due to late detection and identification; Distribution of vaccine; Restricting travel to/from affected cities, states, countries.

Scenario 4: Smallpox Attack on a Shopping Mall¹²⁷Scenario

On the first day of Christmas shopping, a single terrorist releases smallpox in aerosol form into a Chicago area mall via an aerosolizer with a timer attached to a wall near an air circulation vent. Potentially 100,000 people are infected. First symptoms are reported nearly two weeks later during flu season, so no one thinks anything of it. A day after the initial symptoms appear, one of the first patients returns with more serious symptoms and is diagnosed with chicken pox and isolated. The following day, an expert sees infected patients and identifies the disease as smallpox. Officials now recognize hundreds of cases throughout the Chicago area; the public panics and rushes to stores to stock up on food and necessities. Within days, the city is panic-stricken; power is out in areas, and broken water and sewer pipes go unfixed due to people not going to work. Beef sales have dropped due to other parts of the country fearing infected meat. A small supply of vaccine is sent to the city and is only enough to be used by healthcare workers. Quarantine is enforced, and the scenario ends. (Little mention of the timeline is provided.)

Transportation's Role

No immediate response due to late detection and identification; Distribution of vaccine/antibiotics; Restricting travel to/from affected cities, states, countries; Distribution of food and necessities to minimize shortages.

Scenario 5: Mass Casualty Exercise: Smallpox Outbreak¹²⁸Scenario

The scenario opens during one of the hottest summers on record. Regional medical facilities have been swamped with heat-related illnesses and injuries, with four reported deaths. Because of the heat, attendance at indoor events has been at all-time highs throughout the region. Locations/attractions near water have been similarly packed. A children's day care reports a potential case of smallpox. The child is taken to the emergency room and is immediately isolated. Smallpox is initially diagnosed. Over the next two days, four other children at the day care are diagnosed with smallpox. Eleven cases have been reported in the area, and outbreaks have been reported in six other major metropolitan areas in various states throughout the U.S. The CDC is contacted by the third day, and the National Disaster Medical System is activated.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Pneumonic Plague (*Yersinia pestis*)***Scenario 6: Massachusetts Integrated Statewide Exercise Program – RSS TTX***¹²⁹Scenario

The pneumonic plague is covertly released by a terrorist organization at a series of three college hockey games over a two-day period. First flu-like symptoms appear two to three days later (depending on initial release date). There is heavy reporting of illness throughout the

metropolitan area by day four or five after the initial release. Medical officials identify the disease four to five days after initial release; Strategic National Stockpile (SNS) is requested on same day. Sites dispensing the SNS antibiotics are active on days six or seven. Release event (hockey games) determined 10 to 11 days after initial release; dispensing ends and recovery begins.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting air transportation to/from affected region.

Scenario 7: TOPOFF: A Plague Exercise¹³⁰

Scenario

The scenario begins some unknown time after a release of pneumonic plague in aerosol form at the Denver Performing Arts Center. Symptoms have already been reported, and plague is identified. Health care facilities are overwhelmed, with shortages in protective gear and personnel calling in sick. Highway, rail, and air travel to and from Denver's 14 metro counties is restricted. Those showing symptoms are encouraged to seek antibiotic treatment from healthcare facilities, and the healthy are told to stay home. On the second day, a national stockpile supply of antibiotics arrives, but there are problems distributing the supplies. Cases are reported in other states and countries. On the third day, the local health care system begins to shut down due to shortages of staff, beds, ventilators, and antibiotics. The state borders are closed. The scenario ends on day four.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Scenario 8: Decision-Making in a Time of Plague¹³¹

Scenario

An undetected release of aerosolized pneumonic plague occurs in a fictional northeastern city with 2.5 million people in the metro area. The CDC identifies six cases soon after the attack. Within 24 hours, hospitals and morgues are overwhelmed; many hospital employees call in sick. Some violence breaks out in response to the rationing of antibiotics and reserve of supplies for U.S. military. Some begin fleeing the city by car, and local radio stations provide the fastest routes out of the infected area. A neighboring state posts National Guard troops at highway borders to prevent people from the infected area from entering their state. Cases have been reported from at least 10 other states. On day 4, the scenario ends with approximately 15,000 people infected, 3,000 dead in 15 states and some other countries, isolated violence/shootings over distribution of antibiotics, and forced quarantine.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries; Transport of dead bodies (pile-up of

bodies specifically mentioned as a problem); Routing traffic around demonstration/violence points.

Scenario 9: Richmond (VA) Bioterrorism Exercise¹³²

Scenario

A four-day, statewide exercise was held to address weaknesses in the state's mass vaccine/antibiotic distribution system. Exercise began with the first signs of symptoms appearing at local hospitals, with more cases on the second day. The plague was reported to local health departments on the second day. On the third day, the local health departments contacted the state health department, which requested the national stockpile. The first vaccine was administered on the fourth day. Officials realized they needed to develop a transportation plan with the local public transportation authority to ensure elderly and those otherwise incapacitated can get to the distribution centers.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries; Transporting elderly, handicapped, others who can't drive to immunization/treatment centers.

Scenario 10: Mass Casualty Exercise: Plague Outbreak¹³³

Note: This is the lone example of a bioterrorism attack to which people can immediately respond and transportation can play an immediate, active role.

Scenario

The scenario opens amid continued threats from international terrorist groups, with unspecified threat warnings issued by the Office of Homeland Security and the FBI. Local law enforcement authorities have been directed to remain at a high level of alert. The news reports that Israel's borders with Palestinian sectors of the West Bank have been closed after learning of the death of a Palestinian with a strongly suspected case of pneumonic plague. Israeli medical facilities are in chaos, while streets and markets have been deserted. After confirmed diagnosis of plague, medical screening facilities are established. International flights into/out of Tel Aviv are stopped. A generic threat is issued from Islamic Jihad against Israel and America.

Late in the afternoon of the next day, two men of Middle Eastern descent are taken into custody at the Mall of America in Minneapolis. An hour later, the men are diagnosed with plague. That evening, similar reports are made at malls in four other U.S. cities. The CDC is notified. Medical facilities in each city are crowded with fearful patients, only some of whom are symptomatic. Shortly after the news reports the incidents throughout the U.S., a similar incident occurs at the local mall. The scenario ends with the suspected Arabic terrorist appearing to have the plague.

Transportation's Role

Immediate local response; Restricting auto travel from mall to contain those potentially exposed; Restricting and re-routing traffic trying to enter mall; Directing emergency response traffic to/from hospital/mall to transport potentially infected patients to be screened.

Anthrax (*Bacillus anthracis*)

Scenario 11: Anthrax: A Possible Case History¹³⁴

Scenario

The FBI in five U.S. cities, including a fictional northeastern city with approximately 2 million people in which the scenario is based, have received threats of an impending anthrax bioterrorist attack. The threats are considered serious, but information is not passed on to local officials. On the evening of the first day, a truck driving on a highway a mile upwind of a heavily attended football game in an open-air arena in the fictional city releases aerosolized powdered anthrax. The anthrax reaches the stadium and business and residential neighborhoods miles from the release point. 20,000 people were unknowingly infected.

Symptoms are reported two days later at the start of flu season, so nothing abnormal is suspected. On day four, healthcare providers have noticed the surge in patients with similar symptoms and contact local health authorities. Blood samples show a bacterial infection that could be anthrax. No further identification is made or analysis conducted. The CDC is informed at midnight on the fourth day. On day five, isolation is ordered, along with further analysis of blood/tissue samples. In the early evening of the fifth day, anthrax is identified, and city and state health officials, the CDC, and FBI are notified.

Antibiotics are in short supply; supplies are requested from federal and other state sources. Distribution centers are set up at police stations and schools. On day 6, National Guard is called in; violence occurs at distribution centers. On day 7, federal antibiotic supplies arrive and are distributed. The CDC and state health department decree that the dead must be cremated; the decision is protested. By day 8, city employees aren't reporting to work, schools are closed, and looting is reported. Media report that many have died because of slow distribution of antibiotics. The scenario ends with the city paralyzed with fear and a similar threat of anthrax being released in five other U.S. cities.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries; Routing traffic around demonstration/violence points.

Scenario 12: An Anthrax Attack on Washington, D.C.¹³⁵

Scenario

An airplane releases 100 kg of anthrax spores upwind of Washington, D.C.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Scenario 13: Anthrax Test in the New York City Subway System¹³⁶Scenario

In 1966, an actual test of commuters' and train operators' exposure to a simulated anthrax release in the New York City subway system was conducted. During rush hour, undercover military personnel dropped light bulbs filled with a harmless anthrax simulant, *Bacillus subtilis variant Niger*, on tracks and in the ventilation system in the subway system in mid-Manhattan. The military personnel then took air samples on station platforms and tunnels to determine the extent to which a bioagent could spread through the subway tunnels. The test showed a large part of the subway system would be contaminated, spreading to stations and tunnels in the boroughs on the other side of the Hudson River. The anthrax simulant was disseminated without problems or apparent detection by subway personnel or riders. It was later discovered that the simulant may have affected people with weakened immune systems. If this situation had actually occurred, the response would likely be similar to the other scenarios presented, with delayed detection and identification. Thus, transportation's role would be limited.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Scenario 14: Crop-Duster with Anthrax¹³⁷Scenario

Using a crop-duster plane, a single terrorist disperses powdered anthrax spores over a football stadium with 74,000 spectators. 39,000 spectators and 15,000 nearby people are unknowingly infected. Symptoms are diagnosed as a cold or flu. After approximately a week, anthrax is identified. Antibiotic supplies are limited; civil unrest ensues following public notification. Eleven days after the release, antibiotics from the national stockpile are received, but distribution is difficult.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries; Routing traffic around demonstration/violence points.

Scenario 15: Mass Casualty Exercise: Anthrax Outbreak¹³⁸Scenario

The scenario opens with flu season in full force, and a news report of an elementary school child having just died in the Washington D.C. area. The suspected cause of death is anthrax. Flu-like symptoms had been first reported six days earlier. The day after the child's death, three more children (two from the same school) are hospitalized with suspected anthrax infections. Four days after the death, two teens in a neighboring state are diagnosed with anthrax. The two states request assistance from CDC to conduct anthrax screening for all school children in the metropolitan region encompassing both states. The FBI begins to investigate any similarities with the unresolved 2001 anthrax mail attacks in D.C. Seven days after the initial death, eight

other anthrax cases have been diagnosed in the mid-Atlantic region in multiple states. Also, a severe flu outbreak is reported at the Naval Academy and West Point Military Academy, with 650 people hospitalized. An investigation by the DoD begins, and alert is issued to military medical clinics and surrounding communities. The scenario ends eight days after the initial death, with another child dying. His autopsy confirms anthrax is the cause of death.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Other Bioagents

Scenario 16: Highly Pathogenic Avian Influenza (HPAI) Outbreak¹³⁹

Scenario

An unexplained outbreak of HPAI occurs in a subset of birds; infected poultry are of concern for animal-to-human transmission. If an animal influenza breakout occurs during the annual human flu season, co-infection can occur, creating a new human flu strain. Currently, there is no human vaccine for the strain of HPAI mentioned in the article. There is growing scientific concern about a global pandemic of a human-susceptible strain of HPAI.

Transportation's Role

Restricting transport of infected birds.

Scenario 17: Community Reaction to Bioterrorism: Prospective Study of Simulated Outbreak¹⁴⁰

Scenario

Study authors simulated the release of aerosolized Rift Valley fever virus (RVFV) in a semi-rural community (pop. 300,000) in the southern U.S, where mosquitoes could be assumed as the culprit of the RVFV outbreak in a real-life situation. Scenario begins with recognition by the community that there is an unusual infection circulating in humans and farm animals. Over the next nine days, an investigation is conducted, and an intentional release of RVFV is identified by federal authorities. No quarantine is mandated, but the community is isolated due to fear of contagion.

Transportation's Role

No immediate response due to late detection and identification; Distribution of vaccine/antibiotics.

Scenario 18: After-Action Report on the Panhandle Exercise¹⁴¹

Scenario

Three scenarios were considered in which outbreaks of two foreign animal diseases, Foot-and-Mouth Disease (FMD) and Rinderpest,¹⁴² would affect the Texas Panhandle region and four neighboring states with a dense feeder cattle industry. The first scenario considered an outbreak

of FMD near Brownsville in the southern tip of Texas far removed from the Panhandle. Transport (including highway, rail, and air) of animals (cattle and horses – while not susceptible to FMD, horses sometimes come in contact with the same equipment as cattle) and meat, milk, and animal-origin product is the main focus of scenario #1. On any given day, 10,000 cattle trucks might be in transit. The following recommendations were made:

- Animals going to slaughter should proceed, even across state lines.
- Animals going to graze should return to their home facility.
- Animals headed to a feedlot should be stopped in transit. These would need to be held somewhere in isolation.
- Animals at a livestock market could
 - 1) be held at the market, or
 - 2) return to the farm of origin.
- Fresh or frozen product from unaffected areas could go to other markets. Potentially infected product could be
 - 1) destroyed,
 - 2) treated to remove the virus by irradiation, or
 - 3) retained within the affected state or region.

The other two scenarios considered an outbreak of FMD and Rinderpest each within the same feedlot near Hereford, Texas (in the Panhandle). These scenarios were also concerned with restricting the transport of infected animals and product, but the main focus was on carcass disposal and depopulation (slaughter ahead of time normally ready for consumption).

Transportation's Role

Distribution of animal vaccine; Restricting animal and product movement; Transport of carcasses; Movement of animals to isolation facilities.

Scenario 19: Mass Casualty Exercise: Tularemia Outbreak¹⁴³

Scenario

During the evening, an emergency room receives five young, and otherwise healthy male patients who preliminarily test positive for tularemia. Specimens are sent to the State Public Health Lab for confirmation. By the following morning, 16 other patients have reported similar symptoms. Another 16 cases test positive by that afternoon. Hospital staff learns that all those infected had attended the same basketball game three days earlier. The first deaths occur two days after the first diagnosis. The scenario ends four days after the initial case, with a total of 2,281 cases reported in the region.

Transportation's Role

No immediate response due to late detection and identification; Distribution of antibiotics; Restricting travel to/from affected cities, states, countries.

Endnotes

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